



Environmental Surveillance at Los Alamos during 2001



Enhancing Our Stewardship of the Environment

The Laboratory places a priority on simultaneously fulfilling our mission responsibilities and our environmental stewardship responsibilities. The overall goal of our stewardship efforts is to minimize negative impacts and ensure a healthy environment. We monitor our performance to demonstrate the fulfillment of these responsibilities. This annual environmental report describes the 2001 successes of our environmental stewardship. The monitoring information focuses on operations, but it also reports on the results of continued environmental monitoring especially designed to address the special conditions created by the Cerro Grande fire of 2000 and its aftermath. The Laboratory established this additional environmental monitoring and sampling to evaluate whether the fire on Laboratory land adversely impacted public and worker health and the environment. Just as importantly, the program addresses changes from pre-fire baseline conditions and will aid in evaluating any future impacts the Laboratory may have, especially those resulting from contaminant transport off-site.

The program involves a number of different organizations within the Laboratory, as well as coordination with outside organizations and agencies. The primary Laboratory organizations involved are the Air Quality Group (ESH-17), the Water Quality and Hydrology Group (ESH-18), the Hazardous and Solid Waste Group, the Ecology Group (ESH-20), and the Environmental Restoration Project (E-ER).

At the close of 2001, the Laboratory formed a new division—Risk Reduction and Environmental Stewardship (RRES)—and the organizations listed above became a part of RRES. This new division was incorporated to strengthen the Laboratory's commitment to managing the entire life-cycle of nuclear materials from generation to permanent disposal as well as to understanding and safeguarding the natural environment on a local to global scale. Over the next two decades, billions of dollars will be invested globally in managing nuclear materials and waste, cleaning up the environment, and protecting and restoring the natural environment. To this end, RRES has highlighted the following strategic environmental science program thrust areas:

- Natural Resources Protection and Restoration,
- Nuclear Waste and Materials Management, and
- Repository Science.

The role of this new division is to reduce the risk of current and historic Laboratory activities to the public, workers, and the environment through natural and cultural resource protection, pollution prevention, waste disposition, and remediation activities. The new division will serve as the steward of the Laboratory reservation by developing and implementing integrated natural and cultural resource management.

This report summarizes the results of the ongoing routine environmental monitoring and surveillance program, for which the Laboratory collects more than 12,000 environmental samples each year from more than 450 sampling stations in and around the Laboratory. In addition, we have summarized results from sampling for effects of the Cerro Grande fire, especially where the fire has resulted in alterations of trends in environmental conditions seen in past years. We will continue to follow the alterations resulting from the wildfire over the next few years to determine if conditions return to pre-fire levels.

In the aftermath of the events of September 11, 2001, enhanced security actions by the Department of Energy resulted in the removal of many environmental World Wide Web pages from public access. At this writing, it is unknown how many pages these actions have affected and when the pages will be accessible again to the general public. If you have difficulty reaching the sites referenced in this document, please contact me, Lars F. Soholt, Ph.D., at soholt@lanl.gov or 505/667-2256. We will make every attempt to get you the information that you desire.

Environmental Surveillance at Los Alamos during 2001

Environmental Surveillance Program:

Air Quality (Group ESH-17)

505-665-8855

Water Quality and Hydrology (Group ESH-18)

505-665-0453

Hazardous and Solid Waste (Group ESH-19)

505-665-9527

Ecology (Group ESH-20)

505-665-8961





Preface	xxi
Executive Summary	xxiii
1. Introduction	1
Abstract	3
A. Laboratory Overview	3
1. Introduction to Los Alamos National Laboratory	3
2. Geographic Setting	3
3. Geology and Hydrology	4
4. Biology and Cultural Resources	4
B. Management of Environment, Safety, and Health	8
1. Introduction	8
2. Integrated Safety Management	8
3. Environment, Safety, & Health Division	8
a. Air Quality	9
b. Water Quality and Hydrology	9
c. Hazardous and Solid Waste	9
d. Ecology	9
e. Site-Wide Environmental Impact Statement Project Office	9
4. Environmental Management Program	9
a. Waste Management	9
b. Pollution Prevention	10
c. Environmental Restoration Project	11
5. Land Conveyance and Transfer under Public Law 105-119	12
6. Cooperative Resource Management	12
7. Community Involvement	13
8. Public Meetings	14
9. Tribal Interactions	14
10. A Report for Our Communities	15
11. Citizens' Advisory Board	15
C. Assessment Programs	16
1. Overview of Los Alamos National Laboratory Environmental Quality Assurance Programs	16
2. Overview of University of California/Department of Energy Performance Assessment Program	16
3. Environment, Safety, & Health Panel of the University of California President's Council on the National Laboratories	16
4. Division Review Committee	16
5. Cooperative and Independent Monitoring by Other State and Federal Agencies	17
6. Cooperative and Independent Monitoring by the Surrounding Pueblos	17
D. Cerro Grande Fire	17
E. References	19
Figures	
1-1. Regional location of Los Alamos National Laboratory.	5
1-2. Technical areas of Los Alamos National Laboratory in relation to surrounding landholdings	6
1-3. Major canyons and mesas	7
1-4. Cerro Grande fire burn area	18

Table of Contents

2. Compliance Summary	21
Abstract	23
A. Introduction	23
B. Compliance Status	27
1. Resource Conservation and Recovery Act	27
a. Introduction	27
b. Resource Conservation and Recovery Act Permitting Activities	27
c. Resource Conservation and Recovery Act Corrective Action Activities	27
d. Other Resource Conservation and Recovery Act Activities	30
e. Resource Conservation and Recovery Act Compliance Inspection	30
f. Mixed Waste Federal Facility Compliance Order	30
g. Underground Storage Tanks	30
h. Solid Waste Disposal	30
i. Waste Minimization and Pollution Prevention	31
j. Greening of the Government Executive Order	32
k. Resource Conservation and Recovery Act Training	32
l. Hazardous Waste Report	32
m. Hazardous and Solid Waste Amendments Compliance Activities	32
2. Comprehensive Environmental Response, Compensation, and Liability Act	33
3. Emergency Planning and Community Right-to-Know Act	33
a. Introduction	33
b. Compliance Activities	33
4. Emergency Planning under DOE Order 151.1	34
5. Toxic Substances Control Act	34
6. Federal Insecticide, Fungicide, and Rodenticide Act	35
7. Clean Air Act	35
a. New Mexico Air Quality Control Act	35
b. Federal Clean Air Act	39
8. Clean Water Act	40
a. National Pollutant Discharge Elimination System Outfall Program	40
b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program	42
c. National Pollutant Discharge Elimination System Permit Compliance Evaluation Inspection	42
d. National Pollutant Discharge Elimination System Storm Water Program	42
e. National Pollutant Discharge Elimination System Storm Water Program Inspection	44
f. Spill Prevention Control and Countermeasures Program.	44
g. Dredge and Fill Permit Program	44
9. Safe Drinking Water Act	44
a. Introduction	44
b. Radiochemical Analytical Results	46
c. Nonradiological Analytical Results	46
d. Microbiological Analyses of Drinking Water	46
e. Long-Term Trends	46
f. Drinking Water Inspection	46
10. Groundwater	46
a. Groundwater Protection Compliance Issues	46
b. Compliance Activities	48

11.	National Environmental Policy Act	52
a.	Introduction	52
b.	Compliance Activities	52
c.	Environmental Impact Statements, Supplement Analyses, and Special Environmental Analyses	52
d.	Environmental Assessments Completed during 2001	53
e.	Environmental Assessments in Progress during 2001	53
f.	Mitigation Action Plans	53
12.	Integrated Resources Management	55
13.	Cultural Resources	55
a.	Introduction	55
b.	Compliance Overview	55
c.	Compliance Activities	55
14.	Biological Resources including Floodplain and Wetland Protection	56
a.	Introduction	56
b.	Compliance Activities	56
c.	Biological Resource Compliance Documents	57
d.	Effects of the Cerro Grande Fire	57
C.	Current Issues and Actions	57
1.	Compliance Agreements	57
a.	New Mexico Hazardous Waste Management Regulations Compliance Orders	57
b.	Notice of Violation	57
D.	Consent Decree	58
1.	Clean Air Act Consent Decree/Settlement Agreement	58
E.	Significant Accomplishments	58
1.	Follow-Up to the Cerro Grande Fire	58
F.	Significant Events	58
1.	Effects of the Events of September 11	58
G.	Awards	59
1.	Achievement Awards	59
a.	DOE	59
b.	Los Alamos Achievement	59
2.	Pollution Prevention Awards	59
a.	DOE Pollution Prevention Awards	59
b.	Green Zia Awards	60
c.	Laboratory Pollution Prevention Awards	60
H.	References	61
Tables		
2-1.	Environmental Permits or Approvals under Which the Laboratory Operated during 2001	24
2-2.	Waste Generated in 2001 by ER Project Operations	29
2-3.	Environmental Inspections and Audits Conducted at the Laboratory during 2001	31
2-4.	Compliance with Emergency Planning and Community Right-to-Know Act during 2001	34
2-5.	Calculated Actual Emissions for Criteria Pollutants (Tons) Reported to NMED	37
2-6.	Allowable Air Emissions (20 NMAC 2.72)	38
2-7.	National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality and Water Quality Parameters at Industrial Outfalls: Exceedances during 2001	41

Table of Contents

2-8.	2001 SPCC Plans and Tanks	45
2-9.	Radioactivity in Drinking Water (pCi/L) during 2001 by LA County for Compliance Purposes	47
2-10.	Radioactivity in Drinking Water (pCi/L) during 2001 by LANL	48
2-11.	Total Trihalomethanes in Drinking Water (µCi/L) during 2001 by LA County for Compliance Purposes	49
2-12.	Nitrate/Nitrite (as Nitrogen) in Drinking Water (mg/L) during 2001 by LA County for Compliance Purposes	49
2-13.	Inorganic Constituents in Drinking Water (mCi/L) during 2000 by LANL	50
2-14.	Bacteria in Drinking Water at Distribution System Taps during 2001 by LA County for Compliance Purposes	51
2-15.	BART Survey Results for 2001	59
Figures		
2-1.	Criteria pollutant emissions from LANL	37
3. Environmental Radiological Dose Assessment		63
Abstract		65
A.	Overview of Radiological Dose Equivalents	65
B.	Public Dose Calculations	65
1.	Scope	65
2.	General Considerations	66
a.	Direct Radiation Exposure	66
b.	Airborne Radioactivity (Inhalation Pathway)	66
c.	Food (Ingestion Pathway)	66
d.	Water (Ingestion Pathway)	68
e.	Soil (Direct Exposure Pathway)	68
f.	Release of Property	68
C.	Dose Calculations and Results	68
1.	Population within 80 km	68
2.	Off-Site MEI	70
3.	On-Site MEI	70
4.	Doses in Los Alamos and White Rock	70
a.	Los Alamos	71
b.	White Rock	71
5.	Acid Canyon	71
6.	Potential Dose Implications in the Aftermath of the Cerro Grande Fire	71
a.	Exposure Assessment for Lower Los Alamos Canyon	71
b.	Exposure Assessment for Rio Grande Water Users	72
c.	Irrigation Scenario	73
d.	Drinking Water from, Swimming in, or Fishing in the Rio Grande	73
e.	Cattle Watering Scenario	74
f.	Dose Summary and Perspective	74
D.	Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation	74
E.	Effect to an Individual from Laboratory Operations	75
F.	Estimating Radiological Dose to Nonhuman Biota	75
1.	DOE Standard for Evaluating Dose to Aquatic and Terrestrial Biota	75
2.	Comparison of Media Concentrations to Biota Concentrations Guides (BCG) ...	75
Tables		
3-1.	Ingestion Doses from Foods Gathered or Grown in the Area during 2001	67
3-2.	Lower Los Alamos Canyon Annual Dose (mrem)	72
3-3.	Rio Grande Runoff Comparison of 2001 Predicted Peak Concentrations in Unfiltered Water in Rio Grande Runoff	73

3-4.	Monthly Dose from Ingestion of Meat from Cattle that have Watered only in the Rio Grande and only while Runoff from LANL Canyons was Occurring	74
3-5.	Comparison of Media Concentrations to Biota Concentration Guides (BCG) for Protection of Aquatic/Riparian Systems	76
3-6.	Comparison of Media Concentrations to Biota Concentration Guides (BCG) for Protection of Terrestrial Systems	78
Figures		
3-1.	Estimated population around Los Alamos National Laboratory	69
G.	References	79
4.	Air Surveillance	81
	Abstract	83
A.	Ambient Air Sampling	84
1.	Introduction	84
2.	Air Monitoring Network	85
3.	Sampling Procedures, Data Management, and Quality Assurance	85
a.	Sampling Procedures	85
b.	Data Management	85
c.	Analytical Chemistry	85
d.	Laboratory Quality Control Samples	86
4.	Ambient Air Concentrations	86
a.	Explanation of Reported Concentrations	86
b.	Gross Alpha and Beta Radioactivity	86
c.	Tritium	87
d.	Plutonium	88
e.	Americium-241	88
f.	Uranium	89
g.	Gamma Spectroscopy Measurements	90
5.	Investigation of Elevated Air Concentrations	90
6.	Long-Term Trends	92
B.	Stack Air Sampling for Radionuclides	93
1.	Introduction	93
2.	Sampling Methodology	93
3.	Sampling Procedure and Data Management	94
4.	Analytical Results	95
5.	Long-Term Trends	95
C.	Gamma and Neutron Radiation Monitoring Program	96
1.	Introduction	96
2.	Monitoring Network	96
a.	Dosimeter Locations	96
b.	Albedo Dosimeters	96
3.	Quality Assurance	96
4.	Analytical Results	97
a.	Gamma TLD Dosimeters	97
b.	TA-54, Area G	97
c.	TA-18 Albedo Dosimeters	97
D.	Nonradioactive Emissions Monitoring	98
1.	Introduction	98
2.	Air Monitoring Network	98
3.	Sampling Procedures, Data Management, and Quality Assurance	98
4.	Ambient Air Concentrations	99

Table of Contents

a.	Explanation of Reported Concentrations	99
b.	Particulate Matter	99
c.	Inorganic Elements	100
d.	Volatile Organic Compounds	100
5.	Detonation and Burning of Explosives	100
a.	Total Quantities	100
6.	Beryllium Sampling	100
a.	Routine Sampling	100
b.	Special Sampling	101
E.	Meteorological Monitoring	102
1.	Introduction	102
2.	Climatology	102
3.	Monitoring Network	103
4.	Sampling Procedures, Data Management, and Quality Assurance	103
5.	Analytical Results	104
6.	Heavy Rainfall Events Before and After the Cerro Grande Fire	104
F.	Quality Assurance Program in the Air Quality Group	105
1.	Quality Assurance Program Development	105
2.	Field Sampling Quality Assurance	106
3.	Analytical Laboratory Quality Assessment	106
4.	Field Data Quality Assessment Results	106
5.	Analytical Quality Assessment Results	106
6.	Analytical Laboratory Assessments	107
G.	Unplanned Releases	107
H.	Special Studies—Neighborhood Environmental Watch Network Community Monitoring Stations	107
I.	Tables	
4-1.	Average Background Concentrations of Radioactivity in the Regional Atmosphere	109
4-2.	Airborne Long-Lived Gross Alpha Concentrations for 2001	110
4-3.	Airborne Long-Lived Gross Beta Concentrations for 2001	112
4-4.	Airborne Tritium as Tritiated Water Concentrations for 2001	114
4-5.	Airborne Plutonium-238 Concentrations for 2001	116
4-6.	Airborne Plutonium-239 Concentrations for 2001	118
4-7.	Airborne Americium-241 Concentrations for 2001	120
4-8.	Airborne Uranium-234 Concentrations for 2001	122
4-9.	Airborne Uranium-235 Concentrations for 2001	124
4-10.	Airborne Uranium-238 Concentrations for 2001	126
4-11.	Airborne Gamma-Emitting Radionuclides that are Potentially Released by LANL Operations	128
4-12.	Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities	128
4-13.	Airborne Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 2001 (Ci)	129
4-14.	Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 2001 (Ci)	130
4-15.	Radionuclide: Half-Life Information	130
4-16.	Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 2000–2001	131
4-17.	Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at the Waste Disposal Area G during 2000–2001	133
4-18.	Albedo Dosimeter Network	134

4-19.	Airborne Inorganic Element Concentrations for 2001	135
4-20.	Total Suspended Particulate Matter Elemental Ratios	136
4-21.	Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the White Rock Fire Station (ppbv)	137
4-22.	Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Los Alamos Hospital (ppbv)	140
4-23.	Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Intersection of Diamond Drive & East Jemez Roads in Los Alamos (ppbv)	143
4-24.	Air Concentration of Volatile Organic Compounds Not Detected at any Site in 2001 (ppbv)	146
4-25.	DX Division Firing Sites Expenditures for Calendar Year 2000–2001	147
4-26.	Airborne Beryllium Concentrations	148
4-27.	AIRNET QC Sample Types	149
4-28.	Stack QC Sample Types	149
4-29.	NonRadNet QC Sample Types	150
4-30.	QC Performance Evaluation for AIRNET for CY 2001	151
4-31.	QC Performance Evaluation for AIRNET for CY 2001	152
4-32.	QC Performance Evaluation for Stack Sampling for CY 2001	153
4-33.	QC Performance Evaluation for Stack Sampling for CY 2001	154
4-34.	QC Performance Evaluation for Stack Sampling for CY 2001	155
4-35.	QC Performance Evaluation for NonRadNet Sampling for CY 2001	156
J.	Figures	
4-1.	Off-site perimeter and on-site Laboratory AIRNET locations	157
4-2.	Technical Area 54, Area G, map of AIRNET and TLD locations	158
4-3.	Regional and pueblo AIRNET locations	159
4-4.	Annual AIRNET uranium concentrations for 2001	160
4-5.	Uranium-238 decay series	161
4-6.	AIRNET quarterly uranium concentrations (network-wide concentrations excluding site 77)	162
4-7.	AIRNET sites with excess isotopic uranium	162
4-8.	Uranium concentrations at site 77	163
4-9.	Plutonium emissions from sampled Laboratory stacks since 1986	163
4-10.	Uranium emissions from sampled Laboratory stacks since 1986	164
4-11.	Tritium emissions from sampled Laboratory stacks since 1986	164
4-12.	G/MAP emissions from sampled Laboratory stacks since 1986	165
4-13.	Percent of total emissions resulting from plutonium, uranium, tritium, and G/MAP	165
4-14.	Off-site perimeter and on-site Laboratory TLD locations	166
4-15.	ESH-17 barium measurements by ICPES and ICPMS	167
4-16.	Meteorological network	168
4-17.	2001 weather summary for Los Alamos	169
4-18.	2001 total wind roses	170
4-19.	Daytime wind roses	171
4-20.	Nighttime wind roses	172
4-21.	LANL Remote Automated Weather Station (RAWS) locations	173
K.	References	174
5.	Surface Water, Groundwater, and Sediments	177
	Abstract	179
A.	Description of Monitoring Program	181

Table of Contents

1.	Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon	181
2.	DP Canyon and Los Alamos Canyon	182
3.	Sandia Canyon	182
4.	Mortandad Canyon	182
5.	Pajarito Canyon	183
6.	Cañada del Buey	183
7.	Water Canyon and Cañon de Valle	183
B.	Surface Water Sampling	184
1.	Introduction	184
2.	Runoff in 2001	184
3.	Base Flow and Snowmelt Monitoring Network	185
4.	Radiochemical Analytical Results for Base Flow and Snowmelt	185
5.	Nonradiochemical Analytical Results for Base Flow and Snowmelt	186
a.	Major Chemical Constituents	186
b.	Trace Metals	187
c.	Organic Constituents in Base Flow and Snowmelt	188
6.	Long-Term Trends	188
7.	Storm Runoff Monitoring Network	188
8.	Transport of Sediment by Storm Runoff	189
9.	Radiochemical Analytical Results for Storm Runoff	189
a.	Comparison to Historical Levels	189
b.	Fire Impacts on Storm Runoff Quality	190
c.	Comparison of Radioactivity in Storm Runoff with Standards and Screening Levels	190
10.	Nonradiochemical Analytical Results for Storm Runoff	191
a.	Major Chemical Constituents	191
b.	Trace Metals	192
c.	Organic Constituents in Runoff	193
11.	Technical Area 50 Discharges	193
C.	Sediment Sampling	194
1.	Introduction	194
2.	Monitoring Network	194
3.	Radiochemical Analytical Results for Sediments	195
4.	Nonradiochemical Analytical Results	197
a.	Trace Metals	197
b.	Organic Analysis	197
5.	Long-Term Trends	198
D.	Groundwater Sampling	199
1.	Introduction	199
2.	Monitoring Network	199
3.	Radiochemical Analytical Results for Groundwater	201
a.	Radiochemical Constituents in the Regional Aquifer	201
b.	Radiochemical Constituents in Alluvial Groundwater	202
c.	Radiochemical Constituents in Intermediate-Depth Perched Groundwater	203
4.	Nonradiochemical Analytical Results	203
a.	Nonradiochemical Constituents in the Regional Aquifer	203
b.	Nonradiochemical Constituents in Alluvial Groundwater	204
c.	Nonradiochemical Constituents in Intermediate-Depth Perched Groundwater	205
d.	Organic Constituents in Groundwater	205

5.	Long-Term Trends	205
a.	Regional Aquifer	205
b.	Surface Water and Alluvial Groundwater in Mortandad Canyon	206
E.	Groundwater and Sediment Sampling at San Ildefonso Pueblo	207
1.	Groundwater	207
2.	Sediments	208
F.	Sampling Procedures, Analytical Procedures, Data Management, and Quality Assurance	209
1.	Sampling	209
2.	Analytical Procedures	210
a.	Metals and Major Chemical Constituents	210
b.	Radionuclides	210
c.	Organic Compounds	210
3.	Data Management and Quality Assurance	210
a.	Data Management	210
b.	Quality Assurance	211
G.	Unplanned Releases	214
1.	Radioactive Liquid Materials	214
2.	Nonradioactive Liquid Materials	214
H.	Tables	
5-1.	Summary of Discharges from Stream-Monitoring Stations at Los Alamos National Laboratory for Water Year 2001 (October 1, 2000–September 30, 2001)	215
5-2.	Radiochemical Analysis of Snowmelt and Base Flow for 2001 (pCi/L)	216
5-3.	Detections of Radionuclides and Comparison to Standards in Snowmelt and Base Flow for 2001	224
5-4.	Secondary Validation and Laboratory Qualifier Flag Codes	229
5-5.	Chemical Quality of Snowmelt and Base Flow for 2001 (mg/L)	232
5-6.	Perchlorate in Surface Water during 2001 (µg/L)	248
5-7.	Trace Metals in Snowmelt and Base Flow for 2001 (µg/L)	254
5-8.	Number of Samples Collected for Each Suite of Organic Compounds in Surface Water Samples in 2001	264
5-9.	Organic Compounds Detected in Surface Water in 2001 (µg/L)	267
5-10.	Radiochemical Analysis of Storm Runoff for 2001 (pCi/L)	269
5-11.	Chemical Quality of Storm Runoff for 2001 (mg/L)	281
5-12.	Trace Metals in Storm Runoff for 2001 (µg/L)	289
5-13.	Summary of TA-50 Radionuclide, Nitrate, Fluoride, and Perchlorate Discharges	301
5-14.	Radiochemical Analyses of Sediments for 2001 (pCi/g)	302
5-15.	Detections of Greater-Than-Background Radionuclides in River and Stream Sediments for 2001	310
5-16.	Detections of Greater-Than-Background Radionuclides in Reservoir Sediments for 2001	320
5-17.	Total Recoverable Trace Metals in Sediments for 2001 (mg/kg)	322
5-18.	Number of Samples Collected for Each Suite of Organic Compounds in Sediments for 2001	330
5-19.	Organic Compounds Detected in Sediment in 2001 (µg/kg)	333
5-20.	Radiochemical Analyses of Groundwater for 2001 (pCi/L)	338
5-21.	Detections of Radionuclides and Comparison to Standards in Groundwater for 2001	346

Table of Contents

5-22.	Special Regional Aquifer Sampling for Strontium-90 during 2001 (pCi/L)	349
5-23.	Special Water Supply Sampling for Tritium during 2001 (pCi/L)	352
5-24.	Chemical Quality of Groundwater in 2001 (mg/L)	353
5-25.	Perchlorate in Groundwater during 2001 (µg/L)	359
5-26.	Trace Metals in Groundwater for 2001 (µg/L)	368
5-27.	Number of Samples Collected for Each Suite of Organic Compounds in Groundwater in 2001	376
5-28.	Organic Compounds Detected in Groundwater in 2001 (µg/L)	380
5-29.	Quality Assurance Sample Results for Radiochemical Analysis by GEL of Water Samples in 2001 (pCi/L)	381
5-30.	Quality Assurance Sample Results for Chemical Quality Analysis of Water Samples in 2001 (mg/L)	384
5-31.	Quality Assurance Sample Results for Metals Analysis by GEL of Water Samples in 2001 (µg/L)	390
5-32.	Radiological Detections in Quality Assurance Water Samples by GEL in 2001 (pCi/L)	392
5-33.	Chemical Quality Detections in Quality Assurance Water Samples in 2001 (mg/L)	393
5-34.	Trace Metal Detections in Quality Assurance Water Samples in 2001 (µg/L)	395
 I. Figures		
5-1.	Annual snowmelt runoff at upstream and downstream LANL gages and cumulative precipitation for November through May	396
5-2.	Annual seasonal precipitation (June through October) and storm runoff at downstream LANL gages	396
5-3.	Regional base flow and sediment sampling locations	397
5-4.	Storm runoff sampling (gaging) stations in the vicinity of Los Alamos National Laboratory	398
5-5.	Base flow sampling locations in the vicinity of Los Alamos National Laboratory	399
5-6.	Average (volume-weighted) suspended sediment loads in summer storm runoff before and after the Cerro Grande fire	400
5-7.	Gross alpha activity (calculated) in suspended sediment carried by storm runoff before and after the Cerro Grande fire	400
5-8.	Gross alpha activity (calculated) in suspended sediment in various drainages in 2001	401
5-9.	History of plutonium-239, -240 activities in unfiltered storm runoff in lower Pueblo Canyon	401
5-10.	Relationship of annual average radionuclide activity and mineral concentration in RLWTF discharges to DOE DCGs or New Mexico groundwater standards for 1996 to 2001	402
5-11.	Sediment sampling stations on the Pajarito Plateau near Los Alamos National Laboratory	403
5-12.	Sediment and runoff sampling stations at TA-54, Area G	404
5-13.	Sediment sampling stations at TA-49, MDA AB	404
5-14.	Sediment radioactivity histories for selected stations in Acid, Pueblo, DP, and Los Alamos Canyons	405
5-15.	Sediment radioactivity histories for stations on Laboratory lands in Mortandad Canyon	406
5-16.	Springs and deep and intermediate wells used for groundwater sampling	407
5-17.	Observation wells and springs used for alluvial groundwater sampling	408

5-18. Fluoride, nitrate, and perchlorate in RLWTF effluent and Mortandad Canyon groundwater from 1999 through 2001	409
5-19. Molybdenum history in Los Alamos Canyon alluvial groundwater	410
5-20. Annual average radioactivity in Mortandad Canyon	411
5-21. Springs and groundwater stations on or adjacent to San Ildefonso Pueblo	413
5-22. Sediment and surface water stations on or adjacent to San Ildefonso Pueblo	414
J. References	415
6. Soil, Foodstuffs, and Associated Biota	419
Abstract	421
A. Soil Monitoring	422
1. Introduction	422
2. Institutional Monitoring	423
a. Monitoring Network	423
b. Sampling Procedures, Data Management, and Quality Assurance	423
c. Radiochemical Analytical Results (On-Site, Perimeter, and Regional Background Soils)	423
d. Nonradiochemical Analytical Results (On-Site, Perimeter, and Regional Background Soils)	424
e. Long-Term Trends	425
3. Facility Monitoring	426
a. Area G	426
b. DARHT (TA-15)	426
c. Plutonium Processing Facility (TA-55)	427
B. Foodstuffs Monitoring	427
1. Introduction	427
2. Produce	427
a. Monitoring Network	427
b. Sampling Procedures, Data Management, and Quality Assurance	427
c. Radiochemical Analytical Results	427
d. Nonradiochemical Analytical Results	428
3. Milk	429
a. Monitoring Network	429
b. Sampling Procedures, Data Management, and Quality Assurance	429
c. Radiochemical Analytical Results	429
4. Fish	429
a. Monitoring Network	429
b. Sampling Procedures, Data Management, and Quality Assurance	430
c. Radiochemical Analytical Results	430
d. Long-Term (Radionuclide) Trends	430
e. Nonradiological Analytical Results	431
f. Long-Term (Nonradionological) Trends	432
5. Game Animals (Elk and Deer)	432
a. Monitoring Network	432
b. Sampling Procedures, Data Management, and Quality Assurance	433
c. Radiochemical Analytical Results	433
d. Long-Term Trends	433
6. Honey	434
a. Monitoring Network	434
b. Sampling Procedures, Data Management, and Quality Assurance	434
c. Radiochemical Analytical Results	434

Table of Contents

d.	Long-Term Trends	434
7.	Special Foodstuffs Monitoring Studies	434
a.	Prickly Pear	434
b.	Herbal Teas	435
C.	Biota Monitoring	435
1.	Introduction	435
2.	Institutional Surveillance of Organic Analytes in Fish	436
a.	Monitoring Network	436
b.	Sampling Procedures, Data Management, and Quality Assurance	436
c.	Analytical Results (PCBs and TEQs)	437
d.	Analytical Results (Dioxins and Furans)	439
d.	Analytical Results (Pesticides)	440
3.	Facility Monitoring	441
a.	Area G	441
b.	DARHT	443
4.	Special Biological Monitoring Studies	444
a.	Tritium Concentrations in Elk Inhabiting the Pajarito Plateau	444
b.	Contaminant Concentrations in Burned Conifer Tree Bark Collected Within the Los Alamos National Laboratory	444
c.	Contaminant Concentrations in Conifer Tree Bark and Wood Following the Cerro Grande Fire	444
d.	The Evaluation of Techniques for the Collection and Use of Scat and Hair for Noninvasive Genetic Analysis of Free-Ranging Carnivores	445
e.	The Use of Noninvasive Genetic Analysis to Study Distribution and Population Characteristics of Mountain Lion (<i>Puma concolor</i>) and Black Bear (<i>Ursus americanus</i>)	445
f.	Assessing Effects of Herbivory on Vegetation Recovery Following the Cerro Grande Fire	446
g.	Relationship Between Home Range Characteristics and the Probability of Obtaining Successful Global Positioning System (GPS) Collar Positions for Elk in New Mexico	446
h.	Presumptuous Assumptions: Elk and the Pristine	446
i.	Development and Implementation of a Wildlife Management Plan for the Los Alamos National Laboratory	447
j.	A Comparison of Elk and Mule Deer Diets on Los Alamos National Laboratory	447
k.	Spring and Fall Small Mammal Sampling Report for Cañon de Valle and Pajarito Canyon, 2001	447
l.	Medium and Large Mammal Spotlight Surveys 2000–2002	448
m.	Surveys of Fire Effects, Rehabilitation Treatments, Ecosystem Recovery, and Residual Fire Hazards: Second Year after the Cerro Grande Fire	448
n.	Biodiversity of Fauna after the Cerro Grande Fire	449
D.	Acknowledgements	449
E.	Tables	
6-1.	Radionuclide Concentrations in Surface (0- to 2-inch depths) Soils Collected from Regional, Perimeter, and On-Site Locations during 2001	450
6-2.	Mean (\pm SD) Radionuclide Concentrations in Surface (0- to 2-inch depths) Soils Collected from Regional, Perimeter, and On-Site Locations Before (1999) and After (2000 and 2001) the Cerro Grande Fire	452

6-3.	Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ dry) in Surface (0- to 2-inch depth) Soils Collected from Regional, Perimeter, and On-Site Locations during 2000 (after fire)	453
6-4.	Mean ($\pm\text{SD}$) Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ dry) in Surface (0- to 2-inch depths) Soils Collected from Regional, Perimeter, and On-Site Locations Before (1999) and After (2000 and 2001) the Cerro Grande Fire	457
6-5.	Mean Radionuclide Concentrations (Total Propagated Analytical Uncertainty, 99% Confidence Level) in Soils (Dry Weight) Collected from Area G in 2001	459
6-6.	Radionuclide Concentrations (Total Propagated Analytical Uncertainty, 99% Confidence Level) in Surface Soils and Sediments Collected around the DARHT Facility in 2001	460
6-7.	Trace Element Concentrations ($\mu\text{g/g}$ dry) in Surface Soils and Sediments Collected Around the DARHT Facility in 2001	461
6-8.	Plutonium Concentrations in Surface Soils Collected Around the Plutonium Processing Facility (TA-55) in Current and Past Years	462
6-9.	Radionuclide Concentrations in Produce Collected from Regional, Perimeter, and On-Site Locations during the 2001 Growing Season	463
6-10.	Mean ($\pm\text{SD}$) Radionuclide Concentrations in Produce Collected from Regional, Perimeter, and On-Site Locations before (1997–1999) and after (2000 and 2001) the Cerro Grande Fire	469
6-11.	Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ dry) in Produce Collected from Regional, Perimeter, and On-Site Locations during the 2001 Growing Season	472
6-12.	Mean ($\pm\text{SD}$) Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ dry) in Produce Collected from Background, Perimeter, and On-Site Locations before (1999) and after (2000 and 2001) the Cerro Grande Fire	475
6-13.	Radionuclide Concentrations in Game (Predators) Fish Upstream and Downstream of Los Alamos National Laboratory during 2001	477
6-14.	Radionuclide Concentrations in Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 2001	478
6-15.	Mean ($\pm\text{SD}$) Radionuclide Concentrations in Game (Predators) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory before (1999) and after (2000 and 2001) the Cerro Grande Fire	480
6-16.	Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ wet weight) in Game (Predators) Fish (Muscle Fillet) Collected Upstream and Downstream of Los Alamos National Laboratory in 2001	481
6-17.	Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ wet weight) in Nongame (Bottom-Feeding) Fish (Muscle Fillet) Collected Upstream and Downstream of Los Alamos National Laboratory in 2001	483
6-18.	Mean ($\pm\text{SD}$) Total Recoverable Mercury Concentrations ($\mu\text{g/g}$ wet weight) in Bottom-Feeding Fish (Muscle) Collected Upstream and Downstream of Los Alamos National Laboratory before (1991–1999) and after (2000 and 2001) the Cerro Grande Fire	485
6-19.	Radionuclide Concentrations in Muscle and Bone Tissues of Elk Collected from On-Site, Perimeter, and Regional Areas during 1999 and 2000	486
6-20.	Radionuclide Concentrations in Muscle and Bone Tissues of Deer Collected from On-Site, Perimeter, and Regional Areas during 2000	488

Table of Contents

6-21.	Radionuclide Concentrations in Prickly Pear (Fruit) Collected from Regional Background and Perimeter Areas during the 2001 Growing Season	489
6-22.	Total Recoverable Trace Element Concentrations ($\mu\text{g/g}$ dry) in Prickly Pear (Fruit) Collected from Regional and Perimeter Areas during the 2001 Growing Season	491
6-23.	Whole-Body Concentrations ($\mu\text{g/g}$ fresh wt.) of PCBs and TEQs for Catfish Collected from Cochiti and Abiquiu Reservoirs	492
6-24.	Whole-Body Concentration ($\mu\text{g/g}$ wet weight) of PCDD/PCDF and TEQs in Catfish from Cochiti and Abiquiu Reservoirs	494
6-25.	Concentrations (ng/g fresh wt.) of Organochlorine Pesticides in Whole-Body Catfish Collected from Cochiti and Abiquiu Reservoirs	498
6-26.	Radionuclide Concentrations (Total Propagated Analytical Uncertainty, 99% Confidence Level) in Unwashed Vegetation Collected from Area G in 2001	501
6-27.	Radionuclide Concentrations (Total Propagated Analytical Uncertainty, 99% Confidence Level) in Overstory (OS) and Understory (US) Vegetation Collected Around the DARHT Facility in 2001	502
6-28.	Total Trace Element Concentrations ($\mu\text{g/g}$ dry) in Overstory (OS) and Understory (US) Vegetation Collected Around the DARHT Facility in 2001	503
6-29.	Radionuclide Analytical Results from Honey Bee Samples Collected from Colonies Near DARHT and a Control Site in 2000	504
6-30.	Heavy Metal Analytical Results from Honey Bee Samples Collected from Colonies Near DARHT and a Control Site in 2000	505
6-31.	Tritium Concentrations (\pm Counting Uncertainty) in Blood from Elk Collected from LANL and Perimeter Areas 1995–2001	506
F.	Figures	
6-1.	Off-site regional and perimeter and on-site Laboratory soil sampling locations	509
6-2.	Site/sample locations of soils and vegetation at Area G	510
6-3.	Sampling locations at the DARHT facility at TA-15	511
6-4.	Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations	512
6-5.	Mean concentration of total PCBs (from congeners) in whole-body fish from Cochiti Reservoir and Abiquiu reservoirs	513
6-6.	Total PCBs from Aroclors in fish fillets from the Rio Grande in 1997	513
G.	References	514

APPENDIXES

A.	Standards for Environmental Contaminants	523
	Tables	
A-1.	Department of Energy Public Dose Limits for External and Internal Exposures	525
A-2.	Department of Energy's Derived Concentration Guides for Water and Derived Air Concentrations	526
A-3.	National and New Mexico Ambient Air Quality Standards	527
A-4.	Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 2001	528

A-5.	Annual Water Quality Parameters Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 2001	529
A-6.	Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Radiochemicals, Inorganic Chemicals, and Microbiological Constituents	530
A-7.	Livestock Watering Standards	531
A-8.	Wildlife Habitat Stream Standards	531
A-9.	Organic Analytical Methods	532
A-10.	Volatile Organic Compounds	532
A-11.	Semivolatile Organic Compounds	534
A-12.	Polychlorinated Biphenyls	535
A-13.	High-Explosives Analytes	536
	References	536
B.	Units of Measurement	537
	Tables	
B-1.	Prefixes Used with SI (Metric) Units	537
B-2.	Approximate Conversion Factors for Selected SI (Metric) Units	538
B-3.	Common Measurement Abbreviations and Measurement Symbols	538
	Reference	539
C.	Description of Technical Areas and Their Associated Programs	541
D.	Related Web Sites	545

GLOSSARY OF TERMS	547
--------------------------------	------------

ACRONYMS AND ABBREVIATIONS	557
---	------------

DISTRIBUTION	563
---------------------------	------------



Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory), Environment, Safety, and Health Division, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 2001. Chapter 3 provides a summary of the maximum radiological dose a member of the public could have potentially received from Laboratory operations. The environmental data are organized by environmental media (Chapter 4, air; Chapter 5, water; and Chapter 6, soils, foodstuffs, and biota) in a format to meet the needs of a general and scientific audience. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, and Appendix C describes the Laboratory's technical areas and their associated programs.

We've also enclosed a booklet, *Overview of Environmental Surveillance during 2001*, that briefly explains important concepts, such as radiation, and provides a summary of the environmental programs, monitoring results, and regulatory compliance.

Inquiries or comments regarding these annual reports may be directed to

**US Department of Energy
Office of Environment and Projects
528 35th Street
Los Alamos, NM 87544**

or

**Los Alamos National Laboratory
Environment Safety and Health Division
P.O. Box 1663, MS K491
Los Alamos, NM 87545**

To obtain copies of the report, contact

**Lars F. Soholt
Ecology Group, Los Alamos National Laboratory
P.O. Box 1663, MS M887
Los Alamos, NM 87545
Telephone: 505-667-2256
e-mail: soholt@lanl.gov**

**This report is also available on the World Wide Web at
<http://lib-www.lanl.gov/cgi-bin/getfile?LA-13979.htm>**



Los Alamos National Laboratory (LANL or the Laboratory) is managed by the Regents of the University of California (UC) under a contract that is administered by the National Nuclear Security Administration of the Department of Energy (DOE) through the Los Alamos Area Office and the Albuquerque Operations Office. This report presents environmental data and analyses that characterize environmental performance and addresses compliance with environmental laws at the Laboratory during 2001. Using comparisons with standards and regulations, this report concludes that environmental effects from Laboratory operations are small and did not pose a threat to the public, Laboratory employees, or the environment in 2001.

Laboratory operations were in compliance with all environmental regulations and the Environmental Protection Agency's (EPA) Letter of Authorization to dispose of polychlorinated biphenyls (PCBs) at Technical Area (TA) 54, Area G, with the exception of a few exceedances of effluent discharge limits. However, the New Mexico Environment Department issued a Notice of Violation to the DOE and UC, identifying 18 categories of alleged noncompliance with the Hazardous Waste Facility permit to treat, store, or dispose of hazardous chemical waste or the chemical part of radioactive mixed waste.

All newly proposed activities at the Laboratory that could impact the environment were evaluated through the National Environmental Policy Act (NEPA) to determine potential impacts. In 2001, the Laboratory sent 45 NEPA Environmental Review forms to DOE for review. DOE made seven environmental assessment determinations and issued two Findings of No Significant Impact (FONSI) for the Laboratory in 2001. DOE and the Laboratory continued to plan and develop an Integrated Resources Management Plan in 2001 to integrate existing resource management plans and the development of other management plans with LANL's site planning and mission activities.

In this report, we calculate potential radiological doses to members of the public who may be exposed to Laboratory operations. The 2001 Effective Dose Equivalent (EDE) was 1.8 mrem for the air pathway alone. We calculated this dose using EPA-approved methods for air compliance. The EPA's EDE limit for any member of the public from radioactive airborne releases from a DOE facility is 10 mrem/yr. A maximum off-site dose considering all pathways (not just air) was 1.9 mrem. The maximum calculated dose to a member of the public present on-site was 4.2 mrem. Health effects from radiation exposure have been observed in humans only at doses in excess of 10 rem (10,000 mrem). We conclude that the doses calculated here would cause no adverse human health effects. The total dose from natural background radiation is about 360 mrem in this area and can vary by 10 mrem from year to year.

The Laboratory's air quality compliance program includes the development of air quality permits, calculation of nonradioactive air emissions, and radiological dose assessment. During 2001, the Laboratory performed approximately 250 air quality reviews for new and modified projects, activities, and operations to identify all applicable air quality requirements. A number of projects required permits, permit revisions, or administrative notices. Criteria pollutant emissions for 2001 were similar to 2000; sulfur oxide emissions were lower in 2001 because the Laboratory again burned typical amounts of fuel oil in the TA-3 steam plant when compared with quantities burned during the Cerro Grande fire.

The Laboratory reports chemical information to EPA, state, and local authorities under the Emergency Planning and Community Right-to-Know Act (EPCRA). The EPCRA establishes quantity thresholds for reporting. The Laboratory did not have any spills, releases, or leaks to the environment that required reporting. The Laboratory reported the use of 56 chemicals and explosives. The Laboratory also reported the following lead releases: 4.7 pounds released to air, less than 1 pound released to water, 3,799 pounds of on-site land releases from the shooting range, and approximately 7,830 pounds of lead waste shipped off-site for disposal.

Air surveillance at Los Alamos includes monitoring emissions, ambient air quality, direct penetrating radiation, and meteorological parameters to determine the air quality impacts of Laboratory operations. The ambient air quality in and around the Laboratory meets all EPA and DOE standards for protecting the public and workers.

Radioactive materials are an integral part of many activities at the Laboratory, and some of these materials may be vented to the environment through a stack. The Laboratory evaluates these operations to determine impacts on the public and the environment. As of the end of 2001, the Laboratory continuously sampled 30 stacks for the emission of radioactive material to the ambient air. Radioactive air emissions of

Executive Summary

tritium and gaseous mixed activation products (GMAP) were higher in 2001 than in 2000. Changes in Los Alamos Neutron Science Center (LANSCE) operating systems produced increased GMAP emissions. A container with legacy waste at TA-16 failed causing increased tritium emissions. Radioactive air emissions were well below the amounts that could result in an off-site individual receiving a dose equal to the regulatory limit.

Lower ambient air concentrations of plutonium and americium were recorded at TA-54, Area G, during 2001. Radioactive ambient air quality for Laboratory-derived radionuclides during 2001 was very similar to 2000. In 2001, the Laboratory investigated several instances of elevated air concentrations. None of these elevated air concentrations exceeded DOE or EPA protective standards for workers or the public. The Laboratory began a routine nonradioactive ambient air-monitoring program during 2001.

The Laboratory measures levels of external penetrating radiation (the radiation originating from a source outside the body, including x-rays, gamma rays, neutrons, and charged particle contributions from cosmic, terrestrial, and man-made sources) with thermoluminescent dosimeters. Highest doses were measured at locations on-site at TA-54, Area G; LANSCE; TA-21, Area T; TA-18, Pajarito Site; and the Calibration Facility, TA-3-130.

The Cerro Grande fire caused major physical changes in watersheds crossing the Laboratory boundary and resulted in large impacts on water chemistry. When trees and organic material on the forest floor burned, the fire removed material that previously absorbed rainfall, leading to increased runoff and erosion. Metals (for example, aluminum, iron, barium, manganese, and calcium) and fallout radionuclides (cesium-137; plutonium-239, -240; and strontium-90) previously bound to forest materials were concentrated in resulting ash and readily moved by runoff.

In 2001, record peak storm runoff flows from fire-impacted areas occurred in three canyons. The amount of sediment carried by storm runoff continues to be 100 to 1000 times greater than pre-Cerro Grande fire levels. Largely because of the sediment load and associated background concentrations, we measured record levels of many metals and several radionuclides in the storm runoff. Plutonium-239, -240 activities greater than DOE's derived concentration guidelines (DCG) for radiation protection of the public of 100-mrem were exceeded in runoff in lower Pueblo Canyon and were partly attributable to mobilization of LANL legacy materials. Gross alpha activities were greater than public dose DCGs and New Mexico livestock watering standards in about three-fourths of the storm runoff samples. While high alpha activities were measured at stations both above and below the Laboratory, contributions from LANL are indicated at several locations, most pronounced in Pueblo and Los Alamos Canyons and around TA-54, Area G.

The Laboratory also monitors groundwater to determine its quality. The regional aquifer beneath Los Alamos is the primary source of drinking water for the Laboratory and the residents of Los Alamos County, and it provides a portion of the water for Santa Fe. Continued testing of water supply wells in 2001 showed that high-explosives constituents are not present in Los Alamos County or Santa Fe drinking water. Trace levels of tritium are present in the regional aquifer beneath Los Alamos in a few areas where liquid waste discharges occurred. The tritium levels are less than 1/50th of the drinking water standard. Perchlorate (no drinking water standard) and tritium (at 1/500th of the drinking water standard) continued to be found in water supply well O-1 in Pueblo Canyon during 2001. Radioactivity measurements in perched alluvial groundwater that exceeded DOE's 4-mrem DCGs for drinking water or EPA drinking water standards occurred at locations with current or former radioactive liquid waste discharges: DP/Los Alamos Canyon and Mortandad Canyon. The constituents exceeding drinking water DCGs or maximum contaminant levels were tritium, gross beta, strontium-90, and americium-241. Alluvial groundwater is not used for drinking water.

In 2000 and 2001, perchlorate was apparently discovered in a spring issuing along the Rio Grande below the Laboratory and, in 2001, in numerous surface water samples. Evaluation of analytical laboratory methods and reanalysis of samples show that these apparent detections were the result of matrix interference in the analysis rather than the presence of perchlorate. The Laboratory continues to pursue improvements in analytical measurement of perchlorate.

The long-term trends of water levels in the water supply and test wells in the regional aquifer indicate little depletion of the resource because of pumping for the Los Alamos water supply.

Sediment transport associated with surface water runoff is a significant mechanism for contaminant movement. The Laboratory monitors sediments on and near its property and at regional locations for the presence of metals, radionuclides, and organic compounds including high explosives. In 2000, because of the Cerro Grande fire, cesium-137 was found in many sediment samples at much higher values than previously noted; these high levels continued in 2001. In 2001, the sediment samples on Laboratory property in Mortandad Canyon continued to show cesium-137 exceeding screening action levels (SALs—the level at which the Environmental Restoration Project requires further evaluation).

The Laboratory monitors soils both on- and off-site for radionuclides (e.g., tritium, strontium, cesium, uranium, plutonium, and americium) and trace elements (e.g., arsenic, beryllium, cadmium, mercury, and lead). Most radionuclide concentrations (activity) in soils from Laboratory and perimeter sites were nondetectable or within upper-level regional concentrations; the few detectable values that were above regional concentrations were still very low (pCi/g range) and far below SALs. Uranium and plutonium-239, -240 concentrations in soils collected from Laboratory and perimeter areas were statistically higher than regional concentrations; the differences were very low, however. Similarly, most trace elements, with the exception of beryllium and lead in soils from on-site and perimeter areas, were within regional concentrations. Beryllium and lead, however, were far below SALs. Nearly all mean radionuclide and trace element concentrations in soils collected from Laboratory and perimeter areas after two sampling seasons following the Cerro Grande fire were statistically similar to soils collected before the fire. Trend analyses show that radionuclides in soils, particularly tritium, from both on- and off-site areas have been decreasing over time, so that today most radionuclides are approaching or similar to values close to regional levels.

Foodstuff samples from Laboratory and perimeter locations showed that most radioactivity was attributable to natural sources and/or worldwide fallout, and these samples were statistically indistinguishable from foodstuffs collected in 1999 before the Cerro Grande fire. Produce and fish, in particular, because of the concern for airborne contaminants by smoke and fallout ash and contaminants in runoff, respectively, were not significantly affected. Although soils from on-site and perimeter areas contained significantly higher concentrations of beryllium and lead, beryllium was below detection levels in produce, and lead was not significantly higher in produce collected from on-site and perimeter areas compared with regional areas.

Catfish from Cochiti Reservoir downstream of the Laboratory were analyzed for PCB congeners, organochlorine pesticides, and dioxins/furans. We compared these fish with fish collected from Abiquiu Reservoir, an impoundment upstream of LANL. Mean total dioxin-like, whole-body PCB concentrations in fish from Abiquiu and Cochiti were statistically ($\alpha = 0.05$) similar. A comparison with PCB levels measured in the Rio Grande in 1997 implies that sources may exist for PCBs above LANL influences. Dioxins and furans were detected in 62% (48 of 78) of the possible total results in Cochiti fish, and all detected values were below even the most stringent (lowest) toxicological limit. The mean total DDT and metabolites (DDT+DDD+DDE) concentration in fish from Cochiti was significantly higher than the mean concentration in fish from Abiquiu. The primary source of DDT is thought to be a massive aerial application in 1963. These levels of DDT are within regional and national levels and are within limits suggested for the protection of piscivores and fish. We determined that the portion of catfish not usually consumed by humans contains about 75% of the PCBs and 74% of the total DDT and metabolites. No impacts of the Cerro Grande fire on PCB and other organochlorine levels in fish at Cochiti Reservoir were discernable.

In addition to monitoring Laboratory-wide areas, we also assessed several facilities. We monitored radionuclide and trace elements in soil, vegetation, bees, small mammals, and predators at TA-54, Area G, the Laboratory's primary low-level radioactive waste disposal area. Also, we collected soil, vegetation, and bees within and around DARHT, the Laboratory's Dual Axis Radiographic Hydrodynamic Test facility, and soil from around the Plutonium Processing Facility at TA-55 on three different occasions (1984, 1990, and 2001) for plutonium isotope analysis and report those results.

1. Introduction





contributing authors:

Jarrett Airhart, Linda Anderman, Bob Beers, Eleanor Chapman, Jean Dewart, Barbara Grimes, Todd Haagenstad, Ken Hargis, John Isaacson, Julie Johnston, Karen Lincoln, Terry Morgan, Ken Rea, David Rogers, Lars Sohlt

Abstract

This report presents environmental data that characterize environmental performance and addresses compliance with environmental standards and requirements at Los Alamos National Laboratory (LANL or the Laboratory) during 2001. The Laboratory routinely monitors for radiation and for radioactive and nonradioactive materials at Laboratory sites, as well as at sites in the surrounding region. LANL uses the monitoring results to determine compliance with appropriate standards and to identify potentially undesirable trends. This information is then used for environmental impact analyses, site planning, and annual operational improvements. The Laboratory collected data in 2001 to assess external penetrating radiation and concentrations of chemicals and radionuclides in stack emissions, ambient air, surface waters and groundwaters, the drinking water supply, soils and sediments, foodstuffs, and biota. In addition, the Laboratory continued to conduct extensive sampling following the Cerro Grande fire to determine the effects of smoke and fallout ash on the environment and compared these results with the pre-fire results. Using comparisons with standards and regulations, this report concludes that environmental effects from Laboratory operations are small and do not pose a threat to the public, Laboratory employees, or the environment.

A. Laboratory Overview

1. Introduction to Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. Although planners originally expected that the task would be completed by a hundred scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. The Laboratory is managed by the Regents of the University of California (UC) under a contract that is administered by the National Nuclear Security Administration (NNSA) of the Department of Energy (DOE) through the Los Alamos Area Office (LAAO) and the Albuquerque Operations Office.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, US priorities, and the world

community have changed. Los Alamos National Laboratory enhances global security by

- ensuring the safety and reliability of the US nuclear deterrent,
- reducing the global threat of weapons of mass destruction, and
- solving national problems in energy, infrastructure, and health security. (LANL 2001a).

In its Strategic Plan (2001–2006), Los Alamos National Laboratory expresses its vision and role as follows: “We serve the nation by applying the best science and technology to make the world a better and safer place . . . Inseparable from its commitment to excellence in science and technology is LANL's commitment to completing all endeavors in a safe, secure, and cost-effective manner.” (LANL 2001b)

2. Geographic Setting

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 43-square-mile Laboratory is

1. Introduction

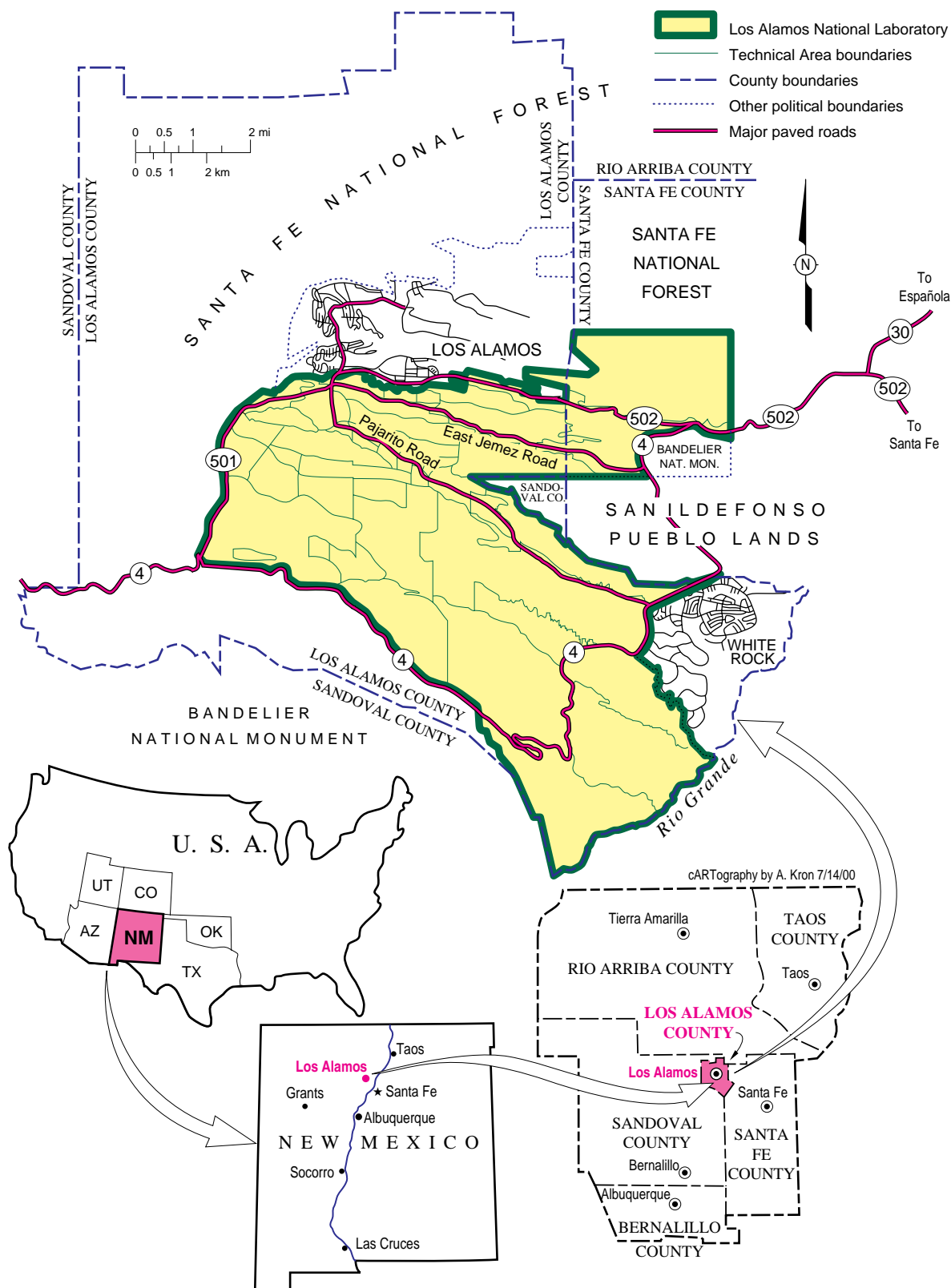


Figure 1-1. Regional location of Los Alamos National Laboratory.

situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft above the Rio Grande Canyon. Most Laboratory and community developments are confined to mesa tops. The surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east.

The Laboratory is divided into technical areas (TAs) that are used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (see Appendix C and Figure 1-2). However, these uses account for only a small part of the total land area; much land provides buffer areas for security and safety and is held in reserve for future use.

3. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major local faults constitute the modern rift boundary, and each is potentially seismogenic. Recent studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-3) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. The tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande. It was deposited by major eruptions in the Jemez Mountains' volcanic center 1.2 to 1.6 million years ago.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick. Surface water in the Los Alamos area occurs primarily as short-lived or intermittent reaches of streams. Perennial springs

on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before they are depleted by evaporation, transpiration, and infiltration.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer of the Los Alamos area, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is under artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of most recharge to the aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. The regional aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mile reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de los Frijoles receives an estimated 4,300 to 5,500 acre-feet annually from the aquifer.

4. Biology and Cultural Resources

The Pajarito Plateau is a biologically diverse and archaeologically rich area. This diversity is illustrated by the presence of over 900 species of plants; 57 species of mammals; 200 species of birds, including 112 species known to breed in Los Alamos County; 28 species of reptiles; 9 species of amphibians; over 1,200 species of arthropods; and 12 species of fish (primarily found in the Rio Grande, Cochiti Reservoir, and the Rito de los Frijoles). No fish species have been found within LANL boundaries. Roughly 20 plant and animal species are designated as threatened species, endangered species, or species of concern at the federal and/or state level.

Approximately 80% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and over 1800 sites have been recorded. More than 85% of the ruins date from the 14th and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100 ft. Almost three-quarters of all ruins are found on mesa tops. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility to the Natural Register of Historic Places.

1. Introduction

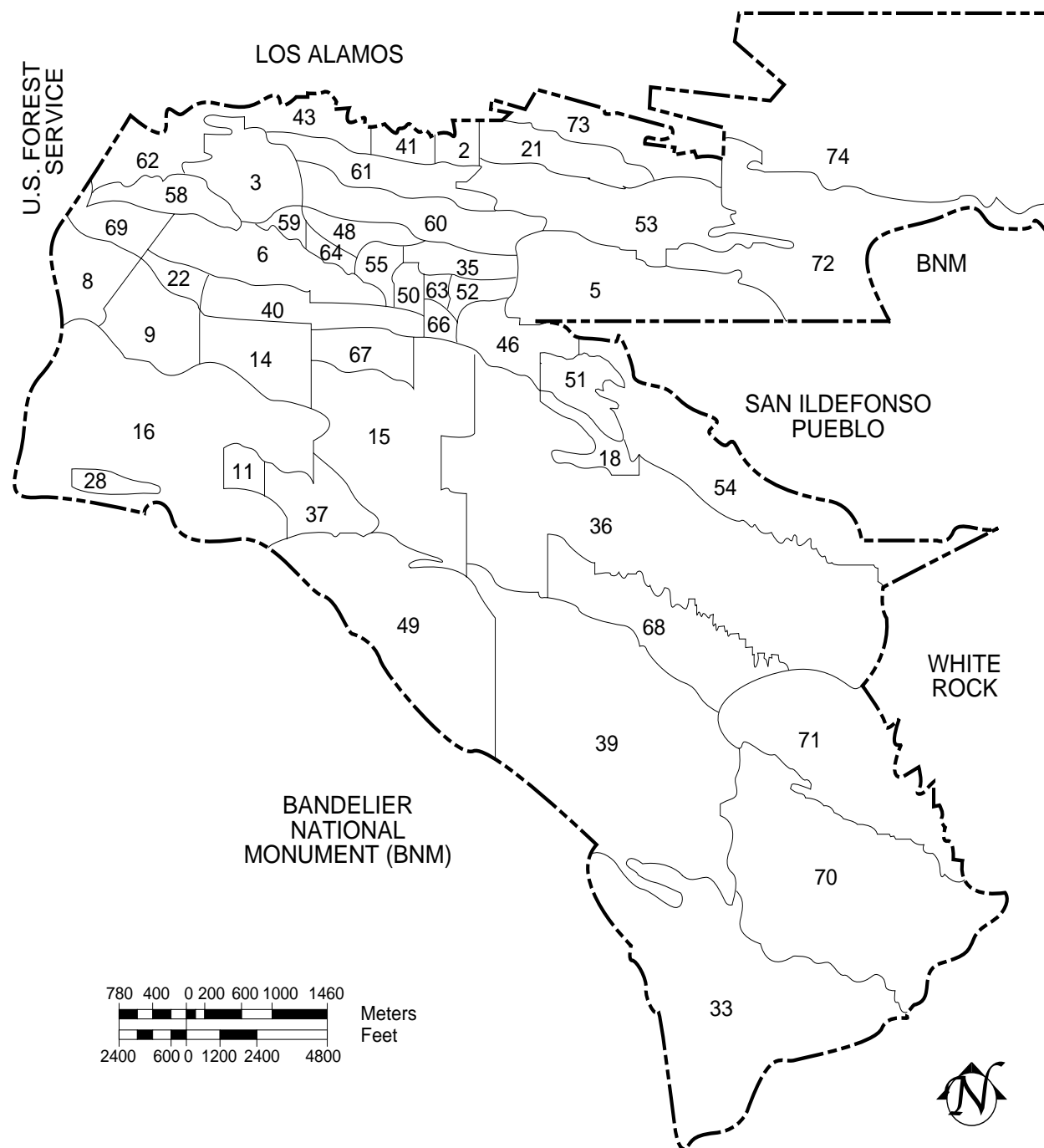


Figure 1-2. Technical Areas of Los Alamos National Laboratory in relation to surrounding landholdings.

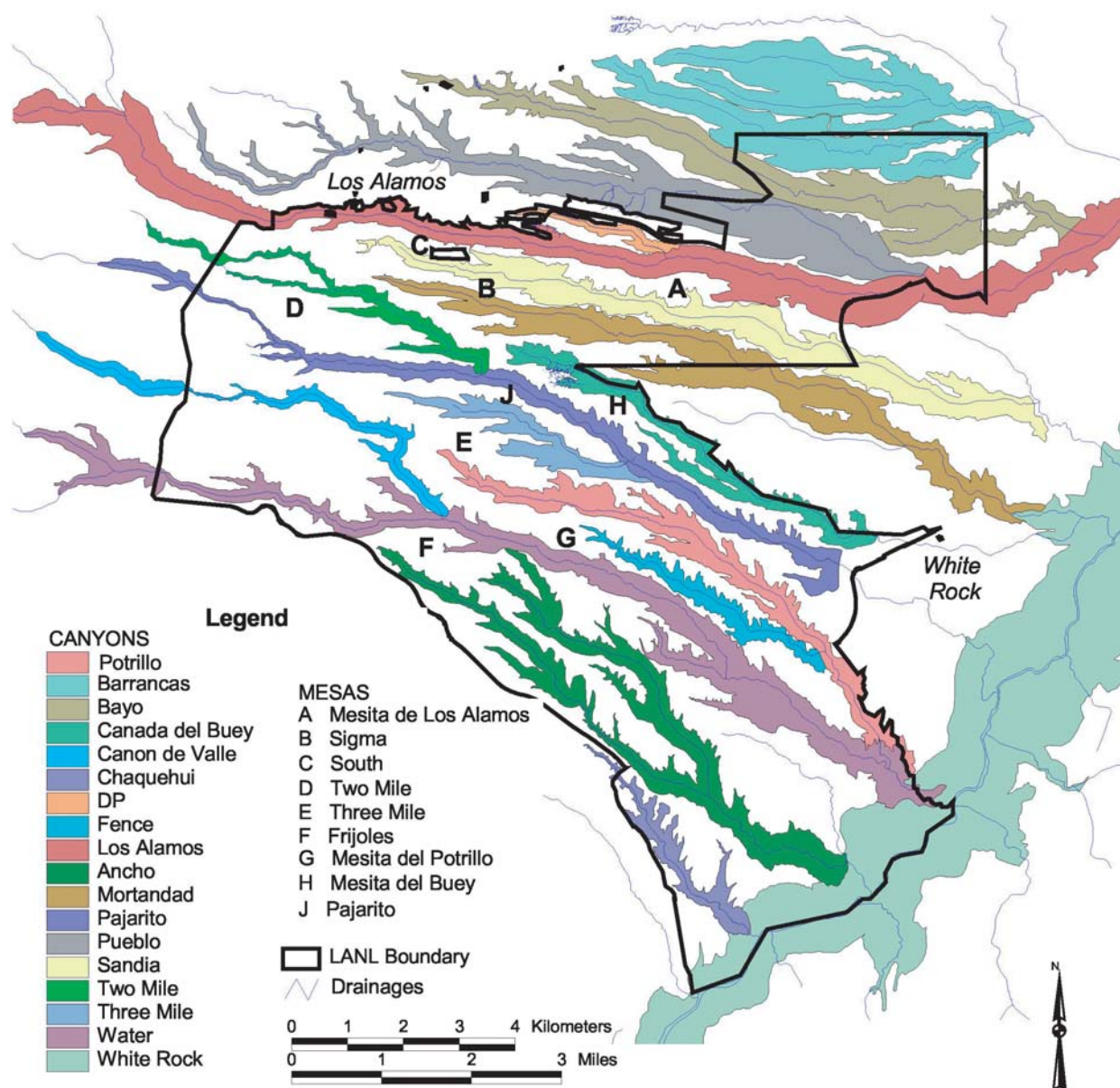


Figure 1-3. Major canyons and mesas.

1. Introduction

B. Management of Environment, Safety, and Health

1. Introduction

The Laboratory's environmental, safety, and health (ES&H) goal is to accomplish its mission cost effectively, while striving for an injury-free workplace, protecting worker and public health, minimizing waste streams, and avoiding unnecessary adverse impacts to the environment from its operations.

2. Integrated Safety Management

Throughout the Laboratory, the goal of Integrated Safety Management (ISM) is the systematic integration of ES&H into work practices at all levels. The term "integrated" indicates that the safety management system is a normal and natural element in performing the work. Safety and environmental responsibility involve every worker. Management of ES&H functions and activities is an integral, visible part of the Laboratory's work planning and work execution processes.

The Laboratory is committed to achieving excellence in environmental, safety, health, and security performance. Laboratory Director John C. Browne says, "We will never compromise safety or security for programmatic or operational needs." Zero environmental incidents means complying with all applicable environmental laws and regulations; adopting practicable proactive approaches to achieve environmental excellence (minimizing waste generation, wastewater discharges, air emissions, ecological impacts, cultural impacts, etc.); preventing unnecessary adverse environmental impacts; and enhancing environmental protection (LANL 1999a).

3. Environment, Safety, & Health Division

The Environment, Safety, & Health (ESH) Division is primarily a Laboratory support organization that provides a broad range of technical expertise and assistance in areas such as worker health and safety, environmental protection, facility safety, nuclear safety, hazardous materials response, ES&H training, occurrence investigation and lessons learned, and quality. ESH Division is in charge of performing environmental monitoring, surveillance, and compliance activities to help ensure that Laboratory operations do not adversely affect human health and safety or the environment. The Laboratory conforms to applicable environmental regulatory requirements and

reporting requirements of DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 231.1 (DOE 1995). ESH Division has responsibility and authority for serving as the central point of institutional contact, coordination, and support for interfaces with ESH regulators, stakeholders, and the public, including the DOE, the Defense Nuclear Facilities Safety Board, the New Mexico Environment Department (NMED), and the Environmental Protection Agency (EPA).

ESH Division provides line managers with assistance in preparing and completing environmental documentation such as reports required by the National Environmental Policy Act (NEPA) of 1969 and the federal Resource Conservation and Recovery Act (RCRA) and its state counterpart, the New Mexico Hazardous Waste Act (HWA), as documented in Chapter 2 of this report. With assistance from Laboratory Counsel, ESH Division helps to define and recommend Laboratory policies for applicable federal and state environmental regulations and laws and DOE orders and directives. ESH Division is responsible for communicating environmental policies to Laboratory employees and makes appropriate environmental training programs available. The environmental surveillance program resides in four groups in ESH Division—Air Quality (ESH-17), Water Quality and Hydrology (ESH-18), Hazardous and Solid Waste (ESH-19), and Ecology (ESH-20)—that initiate and promote Laboratory programs for environmental assessment and are responsible for environmental surveillance and regulatory compliance.

Approximately 600 sampling locations are used for routine environmental monitoring. The maps in this report present the general location of monitoring stations. For 2001, over 250,000 routine analyses for chemical and radiochemical constituents were performed on more than 12,000 routine environmental samples. Laboratory personnel collected many additional samples as they continued to monitor the effects of the Cerro Grande fire. Samples of air particles and gases, water, soils, sediments, foodstuffs, and associated biota are routinely collected at monitoring stations and then analyzed. The results of these analyses help identify impacts of LANL operations on the environment. ESH personnel collect and analyze additional samples to obtain information about particular events, such as major surface water runoff events, nonroutine releases, or special studies. See Chapters 2, 3, 4, 5, and 6 of this report for methods and procedures for acquiring, analyzing, and recording data. Appendix A presents information about environmental standards.

a. Air Quality. ESH-17 personnel assist Laboratory organizations in their efforts to comply with federal and state air quality regulations. ESH-17 personnel report on the Laboratory's compliance with the air quality standards and regulations discussed in Chapter 2 and conduct various environmental surveillance programs to evaluate the potential impact of Laboratory emissions on the local environment and public health. These programs include measuring direct penetrating radiation, meteorological conditions, and stack emissions and sampling for ambient air contaminants.

Chapter 4 contains a detailed exploration of the methodologies and results of the ESH-17 air monitoring and surveillance program for 2001. Personnel from ESH-17 monitor meteorological conditions to assess the transport of contaminants in airborne emissions to the environment and to aid in forecasting local weather conditions. Chapter 4 also summarizes meteorological conditions during 2001 and provides a climatological overview of the Pajarito Plateau.

Dose Assessment. ESH-17 personnel calculate the radiation dose assessment described in Chapter 3, including the methodology and assessments for specific pathways to the public.

b. Water Quality and Hydrology. ESH-18 personnel provide environmental monitoring activities to demonstrate regulatory compliance and to help ensure that Laboratory operations do not adversely affect public health or the environment. ESH-18 provides technical and regulatory support for the Laboratory to achieve compliance with the following major state and federal statutes and regulations: Clean Water Act, including the National Pollutant Discharge Elimination System (NPDES), Spill Prevention Control and Countermeasures Plans (SPCC), and Section 404/401 Dredge and Fill Permitting; New Mexico Water Quality Control Commission Regulations; Federal Insecticide, Fungicide, and Rodenticide Act; and New Mexico Pesticide Control Act. Surveillance programs and activities include groundwater, drinking water, surface water, and sediments monitoring; water supply reporting for Los Alamos County; and the Groundwater Protection Management Program. Chapter 2 contains documentation on the Laboratory's compliance with state and federal water quality requirements. Chapter 5 summarizes the data ESH-18 personnel collected and analyzed during routine monitoring.

c. Hazardous and Solid Waste. ESH-19 personnel provide services in developing and monitor-

ing permits under hazardous and solid waste rules, RCRA/HWA, Solid Waste Act (SWA), and letters of authorization for landfilling polychlorinated biphenyls (PCB) solids contaminated with radionuclides under the Toxic Substances Control Act (TSCA); providing technical support, regulatory interpretation, and Laboratory policy on hazardous, toxic, and solid waste issues and underground storage tank regulations to Laboratory customers; and documenting conditions at past waste sites. Chapter 2 presents the Laboratory's compliance status with hazardous and solid waste regulations.

d. Ecology. Personnel in ESH-20 investigate and document biological and cultural resources within the Laboratory boundaries; prepare environmental reports, including Environmental Assessments required under NEPA; and monitor the environmental impact of Laboratory operations on soil, foodstuffs, and associated biota. Chapter 2 documents the 2001 work in the areas of NEPA reviews and biological and archaeological reviews of proposed projects at the Laboratory. Chapter 6 contains information on the results and trends of the soil, foodstuff, and biota monitoring programs and related research and development activities.

e. Site-Wide Issues Project Office. The Site-Wide Issues Program Office (SWIPO) functions as the land transfer point-of-contact for LANL to facilitate DOE's compliance with the requirements of Public Law 105-119, prepares the annual Site-Wide Environment Impact Statement (SWEIS) Yearbook, and manages the mitigations contained in the Mitigation Action Plan for the SWEIS.

4. Environmental Management Program

a. Waste Management. Waste management activities focus on minimizing the adverse effects of chemical and radioactive wastes on the environment, maintaining compliance with regulations and permits, and ensuring that wastes are managed safely. Wastes generated at the Laboratory are divided into categories based on the radioactive and chemical content. No high-level radioactive wastes are generated at the Laboratory. Major categories of waste managed at the Laboratory are low-level radioactive waste, transuranic (TRU) waste, hazardous waste, mixed low-level waste (waste that is both hazardous and radioactive), and radioactive liquid waste.

The major portion of the inventory of mixed low-level and TRU wastes at the Laboratory was generated before capabilities existed for treatment and disposal

1. Introduction

of those wastes, and the wastes were placed into storage at TA-54. Treatment and disposal capabilities now exist for most of these wastes, and DOE provides funding specifically to address these so-called “legacy wastes” at LANL.

Mixed Low-Level Waste Work-Off. In 1994, LANL had the equivalent of about 3,000 55-gallon drums of mixed low-level waste in storage because no capability existed at either LANL or other locations in the United States for proper treatment and disposal of the waste. At that time, NMED approved a plan called the Mixed Waste Site Treatment Plan to develop and operate treatment technologies and facilities at LANL. The original estimate called for completing the treatment and disposal of the mixed low-level waste in storage in 2006. In cooperation with DOE/LAAO, a team worked to evaluate ways to reduce costs and accelerate the schedule. The team identified new treatment capabilities that were being developed commercially and at other DOE sites, and decisions were made to use those capabilities rather than to continue with new facilities at LANL. NMED also approved these efforts. In addition, efforts began to perform extensive characterization of waste that was only suspected of being both hazardous and radioactive. It is expected that this task will be completed in 2004, two years earlier than originally projected.

Transuranic Waste Inspectable Storage Project. The Transuranic Waste Inspectable Storage Project (TWISP) was established to retrieve 187 fiberglass-reinforced plywood crates and 16,641 metal drums containing solid-form, TRU waste from three earth-covered storage pads. This waste was retrieved under a compliance order from NMED because it was not possible to inspect the waste containers as required by the state hazardous waste regulations. After the waste was retrieved, any damaged containers were over-packed in new containers. The containers were vented and had high-efficiency particulate air (HEPA) filters installed in drum lids. The waste containers were then placed in structures where they can be inspected.

After several years of preparation, DOE granted start-up authority for TWISP in March 1997. Retrieval operations were completed in December 2001. The entire project was completed more than two years earlier than the NMED compliance order and \$19M under budget.

Decontamination and Volume Reduction System. Large metallic items such as gloveboxes, ventilation ducts, and tanks that are stored within fiberglass-reinforced plywood boxes or other large

containers compose about one-third of the legacy TRU waste stored at TA-54. These containers are too large to be shipped for disposal at the Waste Isolation Pilot Plant (WIPP) located east of Carlsbad, New Mexico.

Construction was completed at TA-54 on a new facility called the Decontamination and Volume Reduction System or DVRS. The DVRS includes a 13,200-sq-ft containment area with active ventilation and contamination control, instruments for radioassay of waste items, several processes for decontamination of metal objects, and a large system to shear and crush large metallic objects into drum-sized items. Oversize metallic waste that can be decontaminated to low-level waste will be disposed on-site at TA-54. Waste that remains TRU waste will be placed into drums that can be shipped for disposal at WIPP.

Transuranic (TRU) Waste Characterization, Certification, and Shipment. Transuranic waste must be characterized and certified to meet the Waste Acceptance Criteria at WIPP. LANL was the first DOE site to be granted authorization from DOE to certify TRU waste in September 1997 and made the first of 17 shipments of TRU waste to WIPP in March 1999. During 2000, LANL modified all of its characterization and certification procedures to meet new requirements for shipping mixed TRU waste to WIPP under the hazardous waste facility permit granted to WIPP site by the NMED. LANL made 8 more shipments of TRU waste to WIPP since the hazardous waste permit was issued and expects to make 10 more shipments to WIPP in the coming year.

b. Pollution Prevention. The Laboratory's Prevention Program Office manages the Laboratory's pollution prevention program. Specific waste minimization accomplishments and pollution prevention projects can be seen on the web at <http://emeso.lanl.gov/>. Other waste management activities that reduce waste generation include the following:

- continuing financial incentives for waste reduction and innovative pollution prevention ideas and accomplishments such as the annual Pollution Prevention Awards and Generator Set Aside Fee funding;
- developing databases to track waste generation and pollution prevention/recycling projects;
- providing pollution prevention expertise to Laboratory organizations in source reduction, material substitution, internal recycle/reuse, lifetime extension, segregation, external recycle/reuse, volume reduction, and treatment; and

- providing guidance to divisions within the Laboratory for minimizing waste and pollution through application of the Green Zia tools. Green Zia is a pollution prevention program administered by NMED.

Each year, the Prevention Program Office publishes The Los Alamos National Laboratory Environmental Stewardship Roadmap, in accordance with the Hazardous and Solid Waste Amendments Module VIII of the RCRA Hazardous Waste Permit and 40 CFR 264.73. This document is available at http://emeso.lanl.gov/useful_info/publications/publications.html on the World Wide Web.

One of the six Laboratory excellence goals has an environmental focus: zero environmental incidents. The roadmap document describes the Laboratory's current operations and the improvements that will eliminate the sources of environmental incidents. The stewardship solution for zero incidents is to eliminate the incident source. This goal is being accomplished by continuously improving operations to

- reduce waste generation,
- reduce pollutants released,
- reduce natural resources used, and
- reduce natural resources damaged.

c. Environmental Restoration Project. The Environmental Restoration (ER) Project at the Laboratory augments the Laboratory's environmental surveillance program by identifying and characterizing potential threats to human health, the area's ecology, and the environment from past Laboratory operations. The ER Project's mission is to mitigate those threats, where necessary, through cleanup actions that comply with applicable environmental regulations. Corrective actions may include excavating and/or treating the contamination source, capping and containing a source to prevent its migration, and placing controls on future land use. Often these sources are places where wastes were improperly disposed in the past or where the disposal practices of the past would not meet today's standards. As a result, contamination may have spilled or leaked into the environment from such places called potential release sites or PRSs over time, with the possibility of causing hazards to human health and/or the environment. The ER Project then must confirm or deny the existence of these hazards and cleanup sites, when deemed necessary.

The ER Project organizes its activities according to the natural watersheds across the Laboratory in which

the various PRSs are located. A single watershed comprises one or more mesas and common canyon drainage. The mesas draining into a common canyon may contain multiple contaminated sites. Each of the one or more pieces (called aggregates) contains several PRSs that will be investigated, assessed, and cleaned up (if necessary) as a group. This approach, termed the Watershed-Aggregate Approach, considers the potential risk created by groups of PRSs within a given watershed rather than attempting to apply risk values of individual PRSs. This approach ensures that drinking water sources and sensitive natural resources will be protected as it accounts for potential cumulative impacts of multiple contaminant sources located on mesa tops and slopes.

An exposure scenario serves as the basis for assessing a site for potential risk to human health and defines the pathways by which receptors are exposed. The ER Project determines human health exposure scenarios based on the current and future land use of the site. Standard land-use scenarios the ER Project uses to determine exposure to human health receptors include

- residential,
- industrial,
- recreational, and
- resource user.

Mirenda and Soholt (1999) fully describe standard land-use scenarios. The Comprehensive Site Plan (LANL 1999b) reflects the status of current facility and land use conditions and future Laboratory needs. Industrial land use affects Laboratory workers and is prescribed by the 30-year planning horizon for the Laboratory's mission and the continued operation of present-day facilities. Buffer zone land use may affect recreational users and is based on present and future access to Laboratory property.

The ER Project is continuing to develop and evaluate a set of pathways that would appropriately describe how members of neighboring pueblos use Laboratory lands and environs. The ER Project revised its risk assessment methodology in 1999 to add ecological risk assessments to the human-health risk assessment if warranted by the risk-screening assessment. The ER Project makes corrective action or cleanup decisions on the basis of ecological risks and risks to the environment, in addition to human-health risks. While human-health risk can be evaluated over a relatively small area, ecological risk assessment requires an understanding of the nature and extent of contamination across much larger areas.

1. Introduction

Decisions that are protective of water resources in general also require an understanding of the presence and movement of contamination within an entire watershed.

The ER Project at the Laboratory is structured primarily according to the requirements of the Hazardous and Solid Waste Amendments to RCRA, which refer to these cleanup activities as “corrective actions.” Module VIII of the Laboratory’s Hazardous Waste Facility Permit contains the corrective action provisions. One of the objectives of the ER Project is to complete corrective actions at every site under its purview as necessary. Corrective actions are considered complete when

- the ER Project has demonstrated and documented that the site either poses no risk to human and ecological receptors or that the risk is acceptable—or a final remedy is evaluated, selected, and implemented to reduce or eliminate risk—and
- the administrative authority has concurred.

NMED regulates the Laboratory’s corrective action program under RCRA. The DOE, NMED, and other Laboratory organizations participate on teams that were formed to accelerate environmental restoration through interagency communication and collaborative decision-making at complex and critical path sites. In addition, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) specifies requirements for cleaning up sites that contain certain hazardous substances not regulated by RCRA and for identifying and reporting historical contamination when federal agencies such as DOE transfer surplus property to other agencies or the public. DOE has oversight for those PRSs at the Laboratory that are not subject to RCRA and for the Laboratory’s decommissioning program for surplus buildings and facilities.

The ER Project Installation Work Plan (LANL 2000a) fully documents the watershed approach and the corrective action process. The plan is updated annually as part of the requirements of the RCRA Hazardous Waste Facility permit. See <http://erproject.lanl.gov> on the World Wide Web for additional information about the ER Project. See Chapter 2 for summaries of ER Project activities performed in 2001.

5. Land Conveyance and Transfer Under Public Law 105-119

On November 26, 1997, Congress passed Public Law 105-119. Section 632 of the Act directed the Secretary of Energy to identify parcels of land at or near the

Laboratory for conveyance and transfer to one of two entities: either Los Alamos County or the Secretary of the Interior (to be held in trust for San Ildefonso Pueblo). Pursuant to this legislation, DOE determined that an Environmental Impact Statement (EIS) would be required under NEPA to satisfy the requirements for review of environmental impacts of the conveyance or transfer of each of the ten tracts of land (totaling about 4,800 acres) slated for transfer. DOE may retain portions of these tracts because of current or future national security mission needs or the inability to complete restoration and remediation for the intended use within the time frame prescribed in the Act. The Final Conveyance and Transfer (CT) EIS is dated October 1999 (DOE 1999), and a Record of Decision was issued in January 2000.

Public Law 105-119 also required DOE to evaluate those environmental restoration activities that would be necessary to support land conveyance and transfer and to identify how this cleanup could be achieved within the ten-year window established by law. The resultant report, the *Environmental Restoration Report to Support Land Conveyance and Transfer under Public Law 105-119*, was dated August 1999. In addition, Congress required DOE to issue a Combined Data Report that summarized the material contained in the CT EIS and Environmental Restoration Report. The Combined Data Report to Congress was released in January 2000, and the official notification that these documents were available from the EPA appeared in February 2000. DOE is taking various actions to accomplish the conveyance and transfer of the 10 subject tracts, including actions taken with the assistance of the Laboratory, such as regulatory compliance and environmental restoration activities. These actions will continue until all 10 tracts have been transferred or until the end of 2007 as provided for in Public Law 105-119.

During 2001, the 10 tracts were divided into 28 subparcels to allow for more rapid transfer of those areas not having potential contamination problems to Los Alamos County or the Bureau of Indian Affairs to be held in trust for San Ildefonso Pueblo. By November 2001, Environmental Baseline Surveys had been completed for six subparcels and had been transmitted to the appropriate agencies for review. Actual transfer of these subparcels is expected in September 2002.

6. Cooperative Resource Management

Interagency Wildfire Management Team. The Interagency Wildfire Management Team continues to be

a vehicle for addressing wildfire issues of mutual concern to the regional land management agencies. The team collaborates in public outreach activities, establishes lines of authority to go into place during a wildfire, provides cross-disciplinary training, and shares the expertise that is available from agency to agency. The result of this collaboration has been an increased coordination of management activities between agencies and a heightened response capability in wildfire situations. The Interagency Wildfire Management Team has been instrumental in evaluating and guiding forest thinning activities in the LANL region to minimize the risk and impacts of wildfires. These forest-thinning activities were a critical factor in minimizing some of the spread and impacts of the Cerro Grande fire within Los Alamos County, LANL, and US Forest Service lands bordering LANL. In addition to DOE/NNSA and UC/LANL, regular participants of the Interagency Wildfire Management Team include representatives of the Los Alamos County Fire Department, Santa Fe National Forest, Bandelier National Monument, San Ildefonso Pueblo, NM State Forester's Office, and NMED DOE/NNSA Oversight Bureau.

East Jemez Resource Council. The East Jemez Resource Council remains a highly effective means of improving interagency communication and cooperation in the management of resources on a regional basis. The council includes resource-specific working groups that give resource specialists a forum for a more detailed and technical assessment of resource-specific issues and solutions. The working groups report on progress and issues during the quarterly council meetings. The council is also providing a forum for soliciting regional agency and stakeholder input during the development of the several resource management documents and strategies including the LANL Ecological Risk Assessment Project and the Comprehensive Site Plan. Council participants include Bandelier National Monument, Santa Fe National Forest, NMED, New Mexico State Forestry Division, US Fish and Wildlife Service, NM Department of Game and Fish, San Ildefonso Pueblo, Santa Clara Pueblo, Cochiti Pueblo, Los Alamos County, Rio Arriba County, DOE/NNSA, and UC/LANL.

Cochiti Lake Ecological Resources Team. In 2001, the Cochiti Lake Ecological Resources Team consulted with the US Army Corps of Engineers on the role of Cochiti Lake to address the water and habitat management issues associated with the Rio Grande Silvery Minnow. The team also provided technical expertise in evaluating strategies for assess-

ing the geomorphic condition of the Rio Grande and continued to support the implementation of a rigorous water quality sampling and monitoring study associated with the Cerro Grande fire. Cochiti Lake Ecological Resources Team participants include the US Army Corps of Engineers, Bandelier National Monument, DOE/NNSA Los Alamos Area Office, US Geological Survey, US Fish and Wildlife Service, NM Game and Fish, Cochiti Pueblo, US Forest Service, and UC/LANL.

Pajarito Plateau Watershed Partnership. In 2001, the Pajarito Plateau Watershed Partnership continued to develop a multiagency program and plan to identify and resolve the primary regulatory and stakeholder issues affecting water quality in the watersheds of the Pajarito Plateau region. The partnership's mission is to work together to protect, improve, and/or restore the quality of water in the regional watersheds. The partnership received Clean Water Act Section 319 funding from the EPA to improve regional watersheds impacted by the Cerro Grande fire. Partnership members include Bandelier National Monument, San Ildefonso Pueblo, Santa Clara Pueblo, Los Alamos County, NMED, US Forest Service, DOE/NNSA, and UC/LANL.

7. Community Involvement

The Laboratory continues to encourage public access to information about environmental conditions and the environmental impact of operations at the Laboratory. Although the Community Relations Office has the responsibility to help coordinate activities between the Laboratory and northern New Mexico, many organizations at the Laboratory are actively working with the public. Frequently, these interactions address environmental issues because of the Laboratory's potential impact on local environment, safety, and health.

Outreach

During 2001, Community Relations assigned outreach managers to cover Los Alamos, Santa Fe, Española, and Taos. The Los Alamos center includes a reading room with access to Laboratory documents. Approximately 150 people visited the reading room last year. Access to environmental information is available at outreach centers in Los Alamos and Española. In addition to the activities listed below, the office also helps technical organizations coordinate public meetings, tours, speakers, and other outreach activities as needed including assistance with publications.

1. Introduction

The Communications and Outreach (C&O) Team of the ER Project works actively with the public to provide information for review and comment and to provide opportunities to participate in cleanup decisions. The C&O Team coordinates public involvement activities such as public meetings, tours, media briefings, and other outreach activities for ER Project-specific activities. In 1999, the team published a Web site for the ER Project: <http://erproject.lanl.gov> on the World Wide Web. In 2000, the team developed a “Virtual Library” in the ER Project’s external web site allowing online public access to ER Project documents. In 2001, the C&O Team hired a local small business to scan documents generated from 1990-2000 into portable document files (pdf). These documents and will be available to the public from the online Virtual Library. The team also initiated a focus group outreach initiative for Material Disposal Area (MDA) H activities. The focus group, composed of a diverse group of public, community, and government representatives, will provide a cleanup recommendation to the ER Project and to NMED.

During 2001, the ER Project coordinated and conducted approximately 15 tours of Laboratory facilities and sites for a variety of audiences including DOE, EPA, and NMED; the Northern New Mexico Citizens Advisory Board (CAB); tribal and local governments and environmental staff; and the media. Many tours conducted in 2001 highlighted the impact of the Cerro Grande fire on ER Project-related sites and other ER cleanup activities. In 2001, the C&O Team participated in and/or coordinated approximately 30 meetings. Additionally, over 20 press releases and articles documenting the successful cleanup activities of 2001 were published. Other miscellaneous C&O Team activities included creating poster displays and panels for a number of ER Project-related conferences.

Bradbury Science Museum

Because many of the Laboratory’s facilities are not accessible to the public, the Bradbury Science Museum provides a way for the public to learn about the kinds of work the Laboratory does, whether it is showing how lasers assess air pollution or demonstrating ecological concepts. Attendance at the museum was approximately 85,000 in 2001.

Inquiries

In 2001, the Community Relations Office—with the assistance of a wide variety of Laboratory organizations—responded to questions from members of the public on a variety of topics from the composition of

worldwide nuclear fallout to follow-up questions on the impact of the Cerro Grande fire from the year before. In all, more than 120 questions came in to the reading room.

8. Public Meetings

The Laboratory holds public meetings to inform residents of surrounding communities about environmental activities and operations at the Laboratory. The ER Project C&O Team sponsors ER Project-specific public meetings, informational briefings, poster sessions, open houses, and tours. Topics for public meetings held in 2001 included items of interest identified by the public, quarterly status reports on the Project’s progress cleaning up sites in the Los Alamos town site and in local canyons, and the cleanup of radioactive sludge at a Laboratory facility wastewater lagoon located at TA-53. Additionally, the C&O staff coordinated two public meetings to discuss a Class III Permit Modification Request to remove 25 solid waste management units (SWMUs) from the Laboratory’s Hazardous and Solid Waste Facility Permit. C&O Team staff collaborated extensively with the Interagency Flood Risk Assessment Team and conducted a public meeting on the impacts of the Cerro Grande fire.

9. Tribal Interactions

LANL works with the Accord pueblos and other regional American Indian tribal governments to address issues of concern and implement initiatives to resolve environment, safety, health and other Laboratory-related issues.

Laboratory/tribal interactions in 2001 included the following:

- **UC ESH Panel Meeting.** The environmental program staff managers of each of the Cooperative Agreement Pueblos provided a briefing on their program activities to the University of California President’s Council on the National Laboratories Environment, Safety, and Health Panel at the annual meeting of the pueblos and the panel.
- **Sampling/Monitoring.** Sampling and monitoring of air, water, soils, sediments, foodstuffs, game, and fish continue. Laboratory technical staff work closely with each pueblo’s environmental program staff on such activities. A major concern includes any post-fire contaminant transport through air, surface water, groundwater, soil, and biotic pathways.

- **Environmental Restoration.** The four pueblos participated in the DOE-DP-sponsored LANL and Accord Pueblo Background/Conceptual Site Model Working Meeting, February 6–8, 2001, to review past and present Laboratory activities and releases, the scope and goals of current environmental monitoring and surveillance programs, and the environmental restoration project. The goal of the workshop was to assist the pueblos in developing environmental programs funded by DOE through the Cooperative Agreements.

Working interactions between the Cooperative Agreement Pueblos and the Laboratory Environmental Restoration program have included tours of sites, discussions and review of sampling and analysis plans and work plans, status of land transfer, planning for sampling of TA-74, briefing on the risk assessment results of the analyses of post-flood samples, and risk assessment training.

- **Wildfire Impact.** Monthly meetings between the San Ildefonso cultural resources staff and the Laboratory Cultural Resources Management Team and DOE were set up to address the pueblo's concern about the Cerro Grande wildfire impact on cultural sites and any subsequent rehabilitation activities.

Aerial photographs of the Pajarito Plateau and the Jemez Mountains were taken to document the impacts of the Cerro Grande fire. Santa Clara, San Ildefonso and Cochiti each received a large (approximately 4 ft × 5 ft) color print of the study area and 15 CDs that contain a digital copy of the color ortho imagery.

- **Cerro Grande Rehabilitation Project (CGRP).** In October 2001, the Laboratory signed four task order agreements with area pueblos (San Ildefonso, Santa Clara, Cochiti, and Jemez) to support the Laboratory's Cerro Grande Rehabilitation Project (CGRP). The task order agreement will serve as the basis for a long-term contractual relationship between the Laboratory and the pueblos.
- **Work Plans.** Environmental program staff from each pueblo and Laboratory technical staff held several meetings to develop work plans for this year. The work plans focus on identifying key areas of concern and developing joint plans to address the concerns.
- **Emergencies.** The Pueblo of Santa Clara and Los Alamos National Laboratory signed an Emer-

gency Communication Agreement on December 14, 2000. The intent is to encourage and facilitate communication between the pueblo and the Laboratory in emergency situations. San Ildefonso Pueblo signed a similar agreement in December 2001.

As a follow-up to the Cerro Grande fire experience, the Laboratory designated a place for a pueblo representative in the Laboratory's Emergency Operations Center to be instituted during any emergency occurrence.

10. A Report for Our Communities

In December 2001, ESH Division published the annual report, "For the Seventh Generation: Environment, Safety, and Health at Los Alamos National Laboratory: A Report to Our Communities 2000–2001 Volume V" (ESH 2001). This report gives the Laboratory, its neighbors, and other stakeholders a snapshot of some of the Laboratory ESH programs and issues.

Feature articles in this volume fall into two categories—Partnerships and Progress and Environment and Recovery—and include the following:

Johnson Controls: A Great Partner, A Great Neighbor

Students Organize Archaeological Symposium

Disease Detectives

A Biosafety Posse for Biovillains

Environmental Restoration Project: No Easy Solution, No Quick Fix

The Hydrologic Cycle

Forest Recovery, Naturally

Feeding Habits of Rocky Mountain Elk and Mule Deer

Up Close and Personal: Life after Cerro Grande Project Recovery

This report is available from the Laboratory's Outreach Centers and reading room.

11. Citizens' Advisory Board

The Northern New Mexico Citizens' Advisory Board on Environmental Management was formed in 1995 to provide opportunities for effective communications between the diverse multicultural communities of northern New Mexico, the DOE, the Laboratory, and state and federal regulatory agencies on environmental

1. Introduction

restoration, environmental surveillance, and waste management activities at the Laboratory. ER Project staff participate in the monthly CAB meetings. More information on the CAB is available at <http://www.nnmcab.org> on the World Wide Web.

C. Assessment Programs

1. Overview of Los Alamos National Laboratory Environmental Quality Assurance Programs

Quality is the extent to which an item or activity meets or exceeds requirements. Quality assurance includes all the planned and systematic actions and activities necessary to provide adequate confidence that a facility, structure, system, component, or process will perform satisfactorily. Each monitoring activity ESH Division sponsors has its own Quality Assurance Plan and implementing procedures. These plans and procedures establish policies, requirements, and guidelines to effectively implement regulatory requirements and to meet the requirements for DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 5700.6C (DOE 1991). Each Quality Assurance Plan must address the criteria for management, performance, and assessments.

The ESH groups performing environmental monitoring activities either provide their own quality assurance support staff or can obtain support for quality assurance functions from the Quality Assurance Support Group (ESH-14). ESH-14 personnel perform quality assurance and quality control audits and surveillance of Laboratory and subcontractor activities in accordance with the Quality Assurance Plan for the Laboratory and for specific activities as requested. The Laboratory's Internal Assessment Group (AA-2) manages an independent environmental appraisal and auditing program that verifies implementation of environmental requirements. The Quality Improvement Office manages and coordinates the effort to become a customer-focused, unified Laboratory.

2. Overview of University of California/Department of Energy Performance Assessment Program

During 2001, UC and NNSA evaluated the Laboratory based on mutually negotiated ES&H performance measures. The performance measures are linked to the principles and key functions of ISM. The performance assessment program is a process-oriented approach

intended to enhance the existing ISM system by identifying performance goals.

Performance measures include the following categories:

- environmental performance;
- radiation protection of workers;
- waste minimization, affirmative procurement, and energy and natural resources conservation;
- management walkarounds;
- hazard analysis and control;
- maintenance of authorization basis; and
- injury/illness prevention.

Specific information on the categories and the assessment scoring can be obtained at http://arania.lanl.gov:80/PM_Team/html/App%20F/Appendix%20F%20pp1.htm on the World Wide Web.

3. Environment, Safety, & Health Panel of the University of California President's Council on the National Laboratories (UC-ES&H)

The Environment, Safety, and Health Panel of the University of California President's Council on the National Laboratories held its annual meeting August 15–17, 2001. The agenda included, among others, the following topics:

- the status of Appendix O to the contract between DOE and UC to manage the Laboratory;
- safety at the Laboratory;
- authorization basis facility safety;
- oil spill at the Atlas pulsed-power facility (TA-35) in January 2001;
- Tri-Lab Beryllium Program; and
- the biosafety program.

The panel has not issued a written report summarizing the results of the meeting.

4. Division Review Committee

The ES&H Division Review Committee reviewed ES&H research projects in 2001. The primary purpose of the meeting was to perform the Science & Technology Assessment of ESH Division. The Division Review Committee based its evaluation on the four criteria provided by the UC President's Council on the National Laboratories:

- quality of science and technology;
- relevance to national needs and agency missions;
- support of performance, technical development, and operations of Laboratory facilities; and
- programmatic performance and planning.

The committee assigned an overall grade of outstanding/excellent to the performance of the division for science and technology. The committee found the overall quality improved when compared with 2000 and noticed the shift in focus to fire-related projects. Of the 30 projects evaluated, 13 were truly outstanding or excellent. The projects deemed best in class were

- laser-illuminated track etch scattering (LITES) dosimetry system;
- chronic beryllium disease dosimetry: particle dissolution through lymphocyte activation;
- Bayesian internal dosimetry calculations using Markov chain Monte Carlo;
- assessing potential risks from exposure to natural uranium in well water: Nambé, NM;
- measurements of radioactive air contaminants during the Cerro Grande fire using the LANL air monitoring network (AIRNET); and
- regression modeling to enhance spatial representations of fuel loads and fire hazards.

5. Cooperative and Independent Monitoring by Other State and Federal Agencies

The Agreement-in-Principle between DOE and the State of New Mexico for Environmental Oversight and Monitoring provides technical and financial support for state activities in environmental oversight and monitoring. NMED's DOE Oversight Bureau carries out the requirements of the agreement. The Oversight Bureau holds public meetings and publishes reports on its assessments of Laboratory activities. Highlights of the Oversight Bureau's activities are available at http://www.nmenv.state.nm.us/DOE_Oversight/doetop.html.

Environmental monitoring at and near the Laboratory involves other state and federal agencies such as the Defense Nuclear Facilities Safety Board, the Agency for Toxic Substances and Disease Registry, the Bureau of Indian Affairs, the US Geological Survey, the US Fish and Wildlife Service, the US Forest Service, and the National Park Service.

6. Cooperative and Independent Monitoring by the Surrounding Pueblos

DOE and UC have signed agreements with the four surrounding pueblos. The main purposes of these agreements are to build more open and participatory relationships, to improve communications, and to cooperate on issues of mutual concern. The agreements allow access to monitoring locations at and near the Laboratory to encourage cooperative sampling activities, improve data sharing, and enhance communications on technical subjects. The agreements also provide frameworks for grant support that allow development and implementation of independent monitoring programs.

D. Cerro Grande Fire

On May 4, 2000, the National Park Service initiated a prescribed burn on the flanks of Cerro Grande Peak within the boundary of Bandelier National Monument (LANL 2000b, DOE 2000). The intended burn was a meadow of about 300 acres, at 10,120 ft, located 3.5 mi. west of the Laboratory boundary at TA-16 (Figure 1-4). This technical area is located near the southwest corner of the Laboratory. The prescribed burn was begun in the evening, but, by 1:00 p.m. of the following day, the burn was declared a wildfire.

ESH-17's meteorological data showed above average temperatures and low humidity for the first 10 days of the wildfire. Wind speeds averaged 6 to 17 mph and gusted from 27 to 54 mph during these 10 days. Generally, winds tended to be from the southwest to west during this period.

By day five of the wildfire, May 8, spot fires began to occur on Laboratory lands. By May 10, the fire moved into the town site of Los Alamos and was proceeding north and east across the TA-16 mesa top. The fire was moving eastward down Water Canyon, Cañon de Valle, Pajarito Canyon, and Cañada del Buey by May 11. Eventually the fire extended northward on Laboratory lands to Sandia Canyon and eastward down Mortandad Canyon into San Ildefonso Pueblo lands. The wildfire was declared fully contained on June 6, having burned 43,000 acres of land extending to Santa Clara Canyon on Santa Clara Pueblo lands to the north of the town site. In all, approximately 7,500 acres of Laboratory property was covered by wildfire burn.

1. Introduction

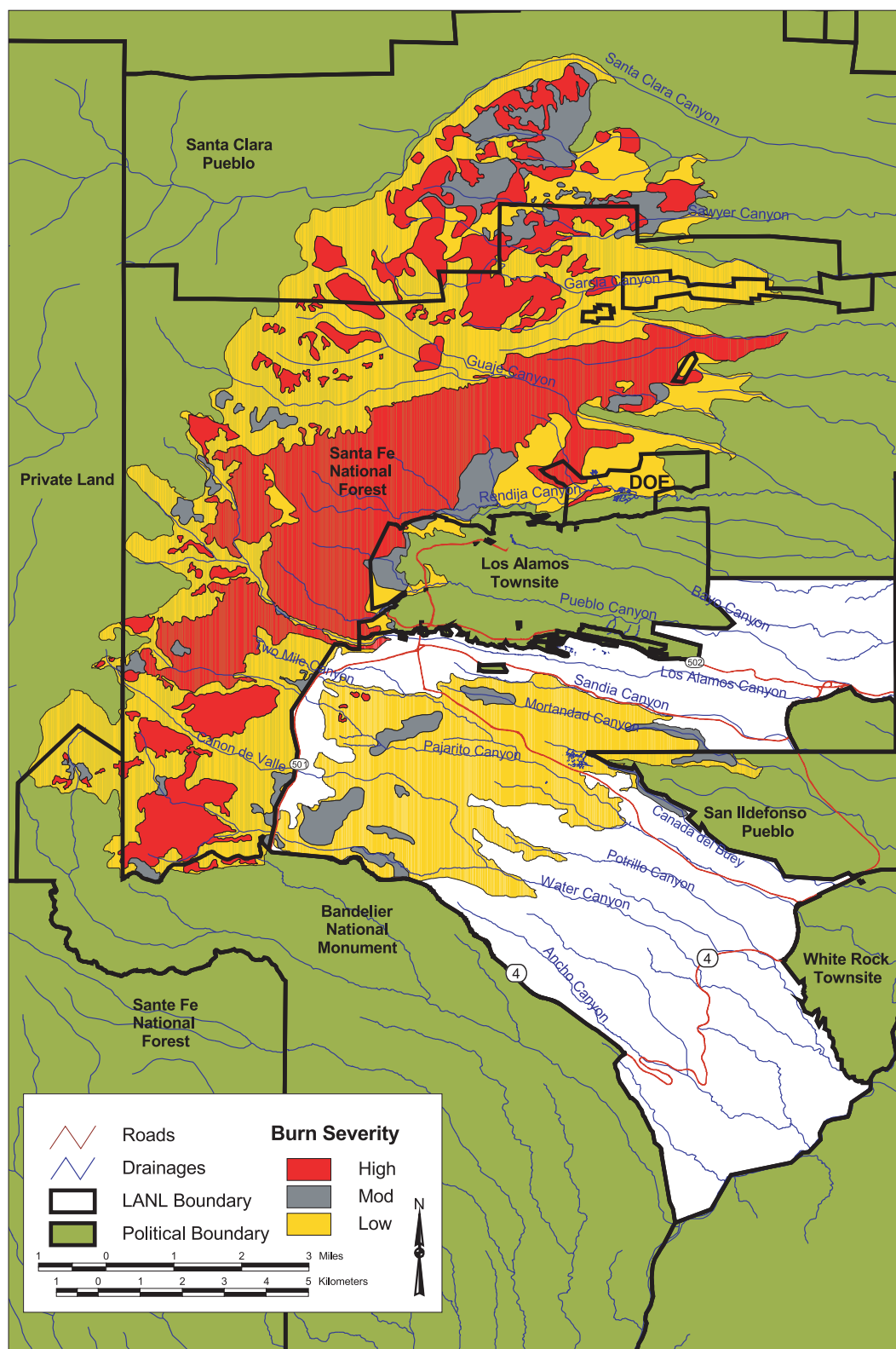


Figure 1-4. Cerro Grande fire burn area.

E. References

- DOE 1988: US Department of Energy, "General Environmental Protection Program," US Department of Energy Order 5400.1 (1988).
- DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1990).
- DOE 1991: US Department of Energy, "Quality Assurance," US Department of Energy Order 5700.6C (1991).
- DOE 1995: US Department of Energy, "Environmental Safety and Health Reporting," US Department of Energy Order 231.1 (1995).
- DOE 1999: US Department of Energy, "Final Environmental Impact Statement for the Conveyance and Transfer of Certain Land Tracts Administered by the Department of Energy and Located at Los Alamos National Laboratory, Los Alamos and Santa Fe Counties, New Mexico," DOE/EIS-0293 (1999).
- DOE 2000: US Department of Energy, "Special Environmental Analysis for the Department of Energy, National Nuclear Security Administration. Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory, Los Alamos, New Mexico," DOE/SEA-03 (2000).
- ESH 2001: "For the Seventh Generation: Environment, Safety, and Health at Los Alamos National Laboratory: A Report to Our Communities 2000–2001 Volume V," Los Alamos National Laboratory document LALP-01-187 (2001).
- Gardner et al., 1999: J. N. Gardner, A. Lavine, G. WoldeGabriel, D. Krier, D. Vaniman, F. Caporuscio, C. Lewis, P. Reneau, E. Kluk, and M. J. Snow, "Structural Geology of the Northwestern Portion of Los Alamos National Laboratory, Rio Grande Rift, New Mexico: Implications for Seismic Surface Rupture Potential from TA-3 to TA-55," Los Alamos National Laboratory report LA-13589-MS (March 1999).
- LANL 1999a: "Integrated Safety Management Description Document," Los Alamos National Laboratory document LA-UR-98-2837, Rev. 3.1 (1999).
- LANL 1999b: "Comprehensive Site Plan 2000," Los Alamos National Laboratory document LA-UR-99-6704 (1999).
- LANL 2000a: Environmental Restoration, "Installation Work Plan for Environmental Restoration Project," Revision 8, Draft (pending approval of administrative authority) Los Alamos National Laboratory document LA-UR-00-1336 (2000).
- LANL 2000b: "A Special Edition of the SWEIS Yearbook. Wildfire 2000," Los Alamos National Laboratory document LA-UR-00-3471 (August 2000).
- LANL 2001a: Los Alamos National Laboratory, Our Mission, <http://int.lanl.gov/goals/>.
- LANL 2001b: Los Alamos National Laboratory, "Strategic Plan (2001–2006)," http://int.lanl.gov/planning/strategic_plan.html.
- Mirenda and Soholt 1999: R. Mirenda and L. Soholt, "Standard Human Health Risk Assessment Scenarios," Los Alamos National Laboratory document LA-UR-99-4399 (August 1999).
- Purtymun and Johansen 1974: W. D. Purtymun and S. Johansen, "General Geohydrology of the Pajarito Plateau," New Mexico Geological Society Guidebook, 25th Field Conference, Ghost Ranch, New Mexico (1974).

2. Compliance Summary





2. Compliance Summary

contributing authors:

Mike Alexander, Gian Bacigalupa, Marc Bailey, Alice Barr, Robert Beers, Bill Brazile, Eleanor Chapman, Jean Dewart, Albert Dye, Todd Haagenstad, Carla Jacquez, Karen Lincoln, Dave McInroy, Chris McLean, Laura Marsh, Charlie Nylander, Dan Pava, Robin Reynolds, Geri Rodriguez, George Vantiem, Steve Veenis

Abstract

Los Alamos National Laboratory (LANL or the Laboratory) staff frequently interacted with regulatory personnel during 2001 on Resource Conservation and Recovery Act (RCRA) and New Mexico Hazardous Waste Act requirements and compliance activities. During 2001, the Laboratory continued to work on the application process to renew its Hazardous Waste Facility permit and to respond to information requests from the New Mexico Environment Department about the history of hazardous waste generation and management at the Laboratory.

In 2001, the Laboratory was in compliance with its National Pollutant Discharge Elimination System (NPDES) permit liquid discharge requirements in 100% of the samples from its sanitary effluent outfalls and in 99.6% of the samples from its industrial effluent outfalls. The Laboratory was in compliance with its NPDES permit liquid discharge requirements in 99.6% of the water quality parameter samples collected in the period from January 1, 2001, through December 31, 2001, at sanitary and industrial outfalls. Concentrations of chemical, microbiological, and radioactive constituents in the drinking water system remained within federal and state drinking water standards.

To Read About . . .	Turn to Page . . .
<i>Resource Conservation and Recovery Act</i>	24
<i>Clean Air Act</i>	35
<i>New Mexico Air Quality Control Act</i>	35
<i>Clean Water Act</i>	40
<i>National Pollutant Discharge Elimination System</i>	40
<i>Safe Drinking Water Act</i>	44
<i>Groundwater</i>	46
<i>National Environmental Policy Act</i>	52
<i>Current Issues and Actions</i>	57
<i>Consent Decree</i>	58
<i>Significant Accomplishments</i>	58
<i>Glossary</i>	547
<i>Acronyms List</i>	557

A. Introduction

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. Laboratory policy implements Department of Energy (DOE) requirements by directing its employees to protect the environment and meet compliance requirements of applicable federal and state environmental protection regulations. Federal and state environmental laws address handling, transport, release, and disposal of contaminants, pollutants, and wastes;

protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and conducting environmental impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental qualities. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. DOE and its contractors are also subject to DOE-administered requirements for control of radionuclides. Table 2-1 presents the environmental permits or approvals these organizations issued and the specific operations and/or sites affected.

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2001

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA Hazardous Waste Facility	Hazardous and mixed waste storage and treatment permit	November 1989	November 1999	NMED
	RCRA General Part B renewal application	submitted January 15, 1999	Administratively continued	
	Request for Supplemental Information	submitted October 2000		MMED
	RCRA mixed waste Revised Part A application	submitted April 1998	---	NMED
	TA-50/TA-54 permit renewal application	submitted January 15, 1999		
	TA-54 Characterization, High-Activity Processing, and Storage Facility	submitted September 19, 2000		NMED
	TA-16 permit renewal application	submitted September 2000		NMED
HSWA	RCRA Corrective Activities	March 1990	December 1999	NMED
			Administratively continued	
TSCA ^a	Disposal of PCBs at TA-54, Area G	June 25, 1996	June 25, 2001	EPA
			Administratively continued	
CWA/NPDES ^b , Los Alamos	Discharge of industrial and sanitary liquid effluents	February 1, 2001	January 31, 2005	EPA
	Storm water permit for industrial activity	December 23, 2000	October 30, 2005	EPA
Storm Water Permit for Construction Activity	DARHT Facility Project	October 2, 1998	July 7, 2003	EPA
	Guaje Well Field Improvements Project	October 2, 1998	July 7, 2003	EPA
	Fire Protection Improvements Project	October 2, 1998	July 7, 2003	EPA
	Strategic Computing Complex Project	May 21, 1999	July 7, 2003	EPA
	Norton Power Line Project	June 1, 1999	July 7, 2003	EPA
	TA-9 to TA-15 Gas Pipeline Replacement Project	August 22, 1999	July 7, 2003	EPA
	Flood Mitigation Project	July 25, 2000	July 7, 2003	EPA
	Nuclear Materials Safeguards and Security Upgrade Project	February 25, 2000	July 7, 2003	EPA
	TA-3 Revitalization Project	March 22, 2001	July 7, 2003	EPA
	TA-55 Fireloop Constructional Project	August 18, 2001	July 7, 2003	EPA
CWA Sections 404/401 Permits	Norton Transmission Line Replacement	March 4, 1999	March 4, 2001	COE/NMED
	Wetland Characterization	May 25, 1999	May 25, 2001	COE/NMED
	Sewer Line Crossing-Upper Sandia Canyon	May 27, 1999	May 27, 2001	COE/NMED
	Lab-wide Gaging Stations/Sci. Meas. Devices Part 2	June 15, 1999	June 15, 2001	COE/NMED

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2001 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401 Permits (Cont.)	TA-9 to TA-15 Natural Gas Line Replacement	June 17, 1999	June 17, 2001	COE/NMED
	TA-48 Wetlands Improvement	July 9, 1999	July 9, 2001	COE/NMED
	TA-72 Firing Range Maintenance	July 13, 1999	July 13, 2001	COE/NMED
	Gas Line Leak Repair-LA Canyon	July 16, 1999	When repair completed	COE/NMED
	Cañon de Valle Filtration Weir	June 25, 1999	June 25, 2001	COE/NMED
	Gaging Station Clean-Outs	February 22, 2000	February 22, 2002	COE/NMED
	PRV Installation near TA-2	February 23, 2000	February 23, 2002	COE/NMED
	R-7 Well Access Road	March 24, 2000	March 24, 2002	COE/NMED
	TA-11 Erosion Control/Fire Road Project	April 11, 2000	April 11, 2002	COE/NMED
	Sandia Canyon Wetland Characterization	April 13, 2000	April 13, 2002	COE/NMED
	Organic Biocontaminants Study	May 26, 2000	May 26, 2002	COE/NMED
	Cerro Grande Emergency Operations	June 23, 2000	June 23, 2002	COE/NMED
	COE Projects	July 20, 2000	July 20, 2002	COE/NMED
	Pajarito Flood Retention Structure	July 18, 2000	July 18, 2002	COE/NMED
	Los Alamos/Pueblo Low Head Weirs	July 23, 2000	July 23, 2002	COE/NMED
	Gas Line Replacement in Los Alamos Canyon	September 18, 2000	September 18, 2002	COE/NMED
	Martin Spring Filtration Weir	October 31, 2000	October 31, 2002	COE/NMED
	PRS 3-056 (c), PCB Cleanup	November 17, 2000	November 17, 2002	COE/NMED
	PRS 16-020 Photo Processing Cleanup	November 22, 2000	November 22, 2002	COE/NMED
Groundwater Discharge Plan, Fenton Hill	Discharge to groundwater	June 5, 2000	June 5, 2005	NMOC ^d
Groundwater Discharge Plan, TA-46 SWS Facility ^e	Discharge to groundwater	January 7, 1998	January 7, 2003	NMED
Groundwater Discharge Plan, Sanitary Sewage Sludge Land Application	Land application of dry sanitary sewage sludge	June 30, 1995	June 30, 2000**	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid Waste Treatment Facility	Discharge to groundwater	submitted August 20, 1996 approval pending		NMED

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2001 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20 NMAC ^f 2.70)	LANL air emissions	not yet issued		NMED
Air Quality (20 NMAC 2.72)	Portable Rock Crusher	June 16, 1999	None	NMED
	TA-3 Steam Plant-Flue Gas Recirculation	September 27, 2000	None	NMED
Air Quality (NESHAP) ^g	Beryllium machining at TA-3-39	March 19, 1986	None	NMED
	Beryllium machining at TA-3-102	March 19, 1986	None	NMED
	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED
Open Burning (20 NMAC 2.60)	Burning of jet fuel and wood for ordnance testing, TA-11	August 18, 1997	December 31, 2002	NMED
	Burning of HE-contaminated ^h materials, TA-14			
	Burning of HE-contaminated materials, TA-16			
	Burning of scrap wood from experiments, TA-36			
	Fuel fire burn of wood or propane, TA-16, Site 1409			
Open Burning (20 NMAC 2.60)	Burning of wood and wood slash from fire mitigation activities around LANL	June 20, 2001	December 31, 2002	NMED

^aToxic Substances Control Act.^bNational Pollutant Discharge Elimination System.^cCorps of Engineers.^dNew Mexico Oil Conservation Division.^eSanitary Wastewater Systems (SWS) Facility.^fNew Mexico Administrative Code.^gNational Emission Standards for Hazardous Air Pollutants.^hHigh-explosive.

** Administratively extended by NMED.

B. Compliance Status

1. Resource Conservation and Recovery Act

a. Introduction. The Laboratory produces a variety of hazardous wastes, most in small quantities relative to industrial facilities of comparable size. The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, creates a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The HSWA emphasize reducing the volume and toxicity of hazardous waste. The applicable federal regulation, 40 Code of Federal Regulations (CFR) 268, requires treatment of hazardous waste before land disposal.

EPA or an authorized state issues RCRA permits to regulate storing, treating, or disposing of hazardous waste and the hazardous component of radioactive mixed waste. A RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous or mixed wastes to be managed, and (4) hazardous waste management methods and units (RCRA hazardous waste management areas). A facility that has submitted a RCRA Part A permit application for an existing unit manages hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance (or denial) of a RCRA Hazardous Waste Facility permit (the RCRA permit). The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management, including contingency response, training, and inspection plans.

In 1996, EPA adopted new standards, under the authority of RCRA, as amended, commonly called “Subpart CC” standards. These standards apply to air emissions from certain tanks, containers, storage facilities, and surface impoundments that manage hazardous waste capable of releasing volatile organic compounds (VOCs) at levels that can harm human health and the environment.

b. Resource Conservation and Recovery Act Permitting Activities. NMED issued the original RCRA Hazardous Waste Facility Permit for the waste management operations at Technical Areas (TAs) 50, 54, and 16 on November 8, 1989. After 10 years, the original permit expired in 1999 but was administratively continued beyond the expiration date (as allowed by the permit and by New Mexico Administration Code, Title 20, Chapter 4, Part 1, as revised

January 1, 1997 [20 NMAC 4.1], Subpart IX, 270.51), because of the timely submittal of permit renewal applications.

To support the renewal of the permit, the Laboratory has provided (1) a General Part B permit application to serve as a general resource document and as the basis for Laboratory facilitywide portions of the final permit and (2) TA-specific permit applications to provide detail on specific waste management units in individual chapters of the final permit.

The Laboratory received or responded to six requests for additional or supplemental information (RSIs) from NMED during 2001. The DOE/LANL responses to these RSIs provide further information or detail about RCRA waste management practices to support the development of the new permit and are part of the administrative record NMED keeps for the permit. LANL developed two RSI responses for the General Part B permit application and submitted them to NMED in February and November. An RSI response for TA-50 was submitted to NMED in November.

The Laboratory received an extensive “Request for Information” for all types of waste, including hazardous and mixed, with supporting waste generation data for the entire LANL operating history from NMED on February 12, 2001. LANL’s response consisted of 12 information submittals between March and July 2001. The information was gathered from all LANL waste management and generating divisions with significant input from the Environmental Restoration (ER) Project. NMED sent RSIs in December 2001 for the TA-16 Part B permit application and to request new closure and post-closure plans for land disposal units at TA-54. In addition, LANL prepared a new Part B permit application revision for the mixed waste management units at TA-55, which was scheduled for submittal to NMED in early January 2002.

c. Resource Conservation and Recovery Act Corrective Action Activities. Solid waste management units (SWMUs) are subject to the HSWA Permit Module VIII corrective action requirements. See previous LANL environmental reports (ESP 2000, ESP 1999, ESP 1998, ESP 1997, ESP 1996) for the history of RCRA closures and other corrective actions.

Corrective Actions. Some 2001 activities included the following.

The removal of contaminated sediments in the South Fork of Acid Canyon, within the Pueblo Canyon watershed, was an ER Project interim action (IA) in 2001. The South Fork of Acid Canyon received untreated wastewater from laboratories at former TA-1

2. Compliance Summary

from 1944 until 1951 and treated wastewater from a radioactive liquid waste treatment facility at former TA-45 from 1951 until 1964. This area was transferred to Los Alamos County in 1967. It is open to the public and crossed by well-used trails. A dose assessment completed in 2000 indicated that no unacceptable levels of radionuclide contamination were present in the canyon. DOE directed the ER Project to prepare an “as low as reasonably achievable” (ALARA) analysis, which led to a decision to plan and implement sediment removal activities. Samples collected from the South Fork of Acid Canyon indicated the presence of plutonium-239, -240; cesium-137; and strontium-90 among others. Sample data also indicated the presence of various metals and organic compounds at levels above background. In 2001, ER Project personnel

- prepared an ALARA analysis for the South Fork of Acid Canyon, which evaluated the costs and benefits of different removal options;
- prepared an IA plan for the removal of contaminated sediment to reduce potential radiation doses to recreational users of the canyon;
- collected 48 sediment samples for analysis at off-site laboratories to help guide cleanup operations and improve waste characterization; and
- began removing sediment with vacuum technology.

By the end of the year, ER excavated approximately 200 yd³ of sediment.

The ER Project characterized and removed six inactive septic tanks at TAs-21, -51, and -54 as part of Voluntary Corrective Actions (VCAs) or IAs in 2001. The contents of each septic tank and the tanks themselves were removed and disposed of in accordance with all applicable EPA, NMED, DOE, and Laboratory requirements. The ER Project prepared VCA completion reports for the septic tanks at TA-51 and TA-54 and submitted them to the appropriate administrative authority (NMED for HSWA potential release sites [PRSs] and DOE for non-HSWA PRSs) with a recommendation for no further action. NMED has concurred verbally with the recommendation for no further action for the two HSWA PRSs, based on a review of the VCA completion report. The ER Project completed confirmation sampling for the area adjacent to and beneath the two septic tanks at TA-21 and will submit VCA/IA completion reports in early 2002.

The ER Project continued a VCA to remove any soil that contained greater than 1 ppm polychlorinated biphenyls (PCB) from a storage area located northeast

of the Johnson Controls Utilities Shop (Building 03-223). The Laboratory’s electrical power line maintenance contractor has used the area for storage of electric cable, used and unused dielectric oils, and PCB-containing transformers, capacitors, and oil-filled drums. The contractor also stored drums containing waste and product solvents at the site between 1967 and 1992. In 2001, ER Project personnel

- removed and disposed of approximately 2400 yd³ of PCB-contaminated soil from the site, including the removal of all sediments from the stream banks on the west slope area and from two drainages in the north area (the west slope, mesa top, and north slope have been excavated down to bedrock);
- collected 86 verification samples from a predetermined hexagonal grid and analyzed them for PCBs (a subset [20 samples] was also analyzed for volatile organic compounds and metals);
- completed site restoration activities; and
- prepared and submitted a VCA report to the EPA and the NMED recommending no further action (NFA) for this site. The EPA approved the NFA.

In 2001, the ER Project completed the drilling and installation of the CdV-R-37-2 well site (a nature-and-extent-of-contamination well that was installed to a depth of 1664 ft to help determine if the high-explosives (HE) contamination that has been detected in the perched and regional aquifers of well R-25 in TA-16 extends to the southeast) and completed hydrologic testing in the well.

The ER Project also conducted extensive characterization of sediments in the tributary to Los Alamos Canyon below the TA-53 surface impoundments to assess potential risk from contaminants in sediments below the outfall, collected 25 sediment samples from 3 different reaches in the tributary canyon, and performed geodetic surveys of the canyon and sampling locations.

Table 2-2 shows the waste quantities ER Project operations generated in 2001, including 5,102 m³ of chemical waste (from RCRA, Toxic Substances Control Act [TSCA], and New Mexico Special Waste categories) in FY 2001. This volume does not include an additional 18,845 m³ of nonhazardous municipal solid waste (sanitary waste).

Closure Activities. Material Disposal Area (MDA) P continued as a major effort for the ER Project. MDA P is located at TA-16 on the south rim of Cañon de Valle on the western edge of the Laboratory. The MDA P

Table 2-2. Waste Generated in 2001 by ER Project Operations

Waste Type	Units	2001 Operations
Chemical ^a	m ³ /yr	5,102
LLW	m ³ /yr	364
MLLW	m ³ /yr	22
TRU	m ³ /yr	0
Mixed TRU	m ³ /yr	0

^a The chemical waste volume includes the categories of RCRA, TSCA, and New Mexico Special Waste and does not include an additional 18,845 m³ of sanitary waste.

landfill began receiving waste from the S-Site Burning Grounds in 1950. Debris from WW-II-era buildings was also disposed of at MDA P. Operation of the landfill was suspended in 1984. ER Project personnel began the closure process at the landfill in 1997.

The presence of detonable HE in the landfill required the use of a robotic excavator. Remote excavation of the landfill began in February 1999 and was completed on May 3, 2000, just before the Cerro Grande fire. Excavation of contaminated soil beneath the landfill using nonremote excavation methods resumed after fire recovery and was completed in March 2001. Phase II confirmatory sampling and geophysics measurements began in June 2001. Phase II sampling found additional contamination. This material was excavated and is staged for off-site disposal pending completion of waste characterization analysis. Additional confirmation sampling will be completed when the waste is shipped.

More than 52,500 yd³ of soil and debris were excavated from MDA P (10,800 yd³ during fiscal year [FY] 2001). During FY 2001, more than 26,700 yd³ of material was shipped for disposal. This amount includes hazardous and industrial waste and recycled material. Waste types and amounts generated include

- 408 lb of detonable HE,
- 820 yd³ of hazardous waste with residual levels of radioactive contamination,
- 6,280 lb of barium nitrate,
- 2,605 lb of asbestos,
- 200 lb of mixed waste,
- 235 ft³ of low-level radioactive waste, and

888 containers that underwent hazardous categorization characterization.

High-Performance Teams. The ER Project maintains High-Performance Teams (HPTs) that include members from the DOE, other Laboratory organizations, and the NMED. The teams were formed to accelerate critical path activities of the ER Project through interagency communication and collaborative decision-making at complex sites. The teams currently include Building 260 Outfall Corrective Measures Study/Corrective Measures Implementation, Airport Landfill, TA-54 RCRA Material Disposal Area Implementation Plan, Ecological Risk, TA-35 Integrated Sampling and Analysis Plan, and Permit Modifications. More detailed information on ER Project activities and accomplishments is available at <http://erproject.lanl.gov>, in the FY 2001 ER Accomplishments Book, and in the quarterly technical reports.

Responses to the Cerro Grande Fire. One year has passed since the Cerro Grande fire's impact on the Los Alamos town site and the Laboratory. Massive fire rehabilitation and flood mitigation efforts have been ongoing and will continue for several years until areas prone to erosion are stabilized. The Cerro Grande fire put nearly 100 of the ER Project's PRSs at increased risk of contaminant release and/or transport, either by virtue of being directly burned or by increasing their vulnerability to surface water runoff or erosion. Since the fire, the ER Project in cooperation with the Water Quality and Hydrology Group (ESH-18) installed controls at these sites and continues to inspect and maintain them as part of the Laboratory's overall storm water program. For an update on the current status of the PRSs impacted by

2. Compliance Summary

the Cerro Grande fire, go to <http://lib-www.lanl.gov/pubs/laur01-4122.htm>.

d. Other Resource Conservation and Recovery Act Activities. The Hazardous and Solid Waste Group (ESH-19) began the self-assessment program in 1995 in cooperation with waste management coordinators to assess the Laboratory's performance in managing hazardous and mixed waste to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. ESH-19 communicates findings from individual self-assessments to waste generators, waste management coordinators, and management to help line managers implement appropriate corrective actions to ensure continual improvement in LANL's hazardous waste program. In 2001, ESH-19 completed 1,134 quarterly self-assessments.

e. Resource Conservation and Recovery Act Compliance Inspection. NMED conducted an annual hazardous waste compliance inspection at the Laboratory from April 23 to the end of August 2001. Section C.1.b presents a summary of the issues identified during the inspection that were included in the NMED Notice of Violation (NOV) issued on October 9, 2001.

f. Mixed Waste Federal Facility Compliance Order. The Laboratory met all 2001 Site Treatment Plan (STP) deadlines and milestones. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order (CO) to both DOE and the University of California (UC) requiring compliance with the STP. That plan documents the use of off-site facilities for treating mixed waste generated at LANL stored more than one year (Section 3004[j] of RCRA and 40 CFR Section 268.50). The Laboratory treated and disposed of over 650 m³ of STP mixed waste through 2001.

g. Underground Storage Tanks. The Laboratory had two underground storage tanks (USTs) (as defined by 40 CFR Part 280) in operation during 2001, designated as TA-16-197 and TA-15-R312-DARHT.

TA-16-197 is a 10,000-gal. UST for unleaded gasoline at a single-pump station for fueling Laboratory service vehicles located at and around TA-16. TA-15-R312-DARHT is a 10,000-gal. UST that captures and stores any accidental releases from an equipment room located at the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility. If a pipe breaks or a leak occurs in the equipment room, all fluids enter

floor drains that discharge to the UST. This tank is normally empty and is only used as a secondary containment system during an accidental spill. Substances that could potentially enter the tank are mineral oil and glycol. Both USTs are double-walled with double-wall piping. Both tanks have leak-detection systems. TA-16-197 has a cathodic corrosion protection system. TA-15-R312-DARHT is a fiber-glass tank that does not require a corrosion protection system. NMED inspected the TA-16-197 UST during 2001 (see Table 2-3). The inspector noted a record keeping deficiency that LANL corrected.

The decontamination and decommissioning (D&D) of the Sherwood Building (TA-3-105) revealed three old USTs. These tanks, TA-3-107, -108, and -109, stored dielectric oil until the 1960s. The NMED was notified, and a UST Bureau representative observed the removal of the tanks. All of the tanks were intact and empty at the time of removal. Sampling of the soil immediately below the tanks indicated the presence of elevated total petroleum hydrocarbon (TPH), which required a corrective action notice to NMED. An extent of contamination investigation will be conducted at the site in 2002.

h. Solid Waste Disposal. The Laboratory has a commercial/special-waste landfill located at TA-54, Area J, that is subject to NM Solid Waste Management Regulations (NMSWMR). The Laboratory submitted a closure plan for Area J to NMED in May 1999. LANL proceeded to close Area J in 2001 by backfilling the pits with clean fill. Cover material and reseeded of the site will proceed in 2002.

In 2001, LANL completed the required Solid Waste Facility annual report for 2000. Personnel from the NMED Solid Waste Bureau did not inspect Area J during 2001.

LANL sends sanitary solid waste (trash), concrete/rubble, and construction and demolition debris to the Los Alamos County Landfill on East Jemez Road for disposal. DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County owns and operates this landfill and is responsible for obtaining all related permits for this activity from the state. The landfill is registered with the NMED Solid Waste Bureau. The Laboratory contributed 9% (5,110 tons) of the total volume of trash landfilled at this site during 2001, a significant decrease from last year's total volume of 14,237 tons that can be attributed to the Laboratory's waste reduction program. Residents and businesses in Los

Table 2-3. Environmental Inspections and Audits Conducted at the Laboratory during 2001

Date	Purpose	Performing Agency
4/5/01	UST Inspection	NMED ^b
4/23–8/01	RCRA Compliance Inspection	NMED ^b
4/26/01	NPDES Storm Water Program	NMED ^b /SWQB ^c
10/24/01	Asbestos inspection at TA-40 Bldgs. 73 and 74	NMED ^b
10/25/01	Asbestos inspection at TA-46 Bldgs. 86 and 87	NMED ^b

[No NPDES Outfall, Storm Water, FIFRA, SDWA, 404/401, Ground Water Discharge Plan, PCB, or Area J inspections were conducted in 2001. Also no beryllium inspections were conducted (one request for information, no site visit).]

^aRisk Assessments Corporation.

^bNew Mexico Environment Department.

^cSurface Water Quality Bureau.

Alamos County and the City of Española contributed the remaining 91% of the total waste volume. Laboratory trash landfilled included 1,977 tons of trash, 2,504 tons of concrete/rubble, and 452 tons of construction and demolition debris. During 2001, the Laboratory also sent 140 tons of brush for composting and 36 tons of metal for recycling to the county landfill.

i. Waste Minimization and Pollution Prevention. To comply with the HSWA Module of the RCRA Hazardous Waste Facility permit, RCRA Subtitle A, DOE Order 5400.1, Executive Order (EO) 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, and other regulations, the Laboratory must have a waste minimization and pollution prevention program. A copy of that Laboratory program, the *2001 Environmental Stewardship Roadmap*, is located at http://emeso.lanl.gov/useful_info/publications/publications.html on the World Wide Web. Section 1003 of the Waste Disposal Act cites minimizing the generation and land disposal of hazardous wastes as a national objective and policy. It also requires handling all hazardous waste in ways that minimize the present and future threat to human health and the environment. The Waste Disposal Act promotes process substitution; materials recovery, recycling, and reuse; and treatment as alternatives to land disposal of hazardous waste.

The 2001 Annual Report on Waste Generation and Waste Minimization Progress as required by DOE Order 5400.1 provides the amounts of routine, nonroutine, and total RCRA-hazardous, low-level, and mixed low-level wastes Laboratory operations generated during FY 2001. See <http://www.doep2.org/wastemin/> on the World Wide Web for a copy of this report and additional information about waste minimization. DOE defines routine/normal waste generation at LANL as waste generated from any type of production, operation, analytical, and/or research and development (R&D) laboratory operations; treatment, storage, and disposal (TSD) operations; work for others; or any other periodic and recurring work that is considered ongoing in nature. Nonroutine/off-normal waste generation is defined as one-time operation waste such as wastes produced from ER Project activities, including primary and secondary wastes associated with removal and remediation operations, and wastes associated with the legacy waste program cleanup and D&D operations.

The Laboratory is working to achieve the Pollution Prevention and Energy Efficiency Leadership Goals set by DOE. The goals and DOE's plan to meet them can be viewed at <http://www.doep2.org/p2plan.asp>. The Laboratory analyzes waste generation data to identify pollution prevention opportunities in its efforts to continually improve its performance toward meeting these goals.

2. Compliance Summary

j. Greening of the Government Executive Order. The Laboratory purchases EPA-designated products made with recovered materials in support of EO 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition," signed by President Clinton on September 14, 1998, and to comply with RCRA section 6002. EPA designates the categories of these items, referred to as Affirmative Procurement. Based on past reports, the Laboratory purchases the largest number of items in three categories: paper, toner cartridges, and plastic desktop accessories whenever available. The Laboratory submits a summary report to DOE after each fiscal year end and is required to report quarterly to UC on the Affirmative Procurement Rate. Procurement personnel and the Environmental Stewardship Office are working with Laboratory vendors to provide purchasers with a wide variety of recycled content items in the Just-In-Time purchasing system.

k. Resource Conservation and Recovery Act Training. The RCRA training program is a required component of, and is described in, the RCRA Hazardous Waste Facility Permit. The Laboratory training program is in compliance and, with the exception of annual refresher course revisions and a one-course addition, experienced only minor modifications and revisions in 2001 to reflect regulatory, organizational, and/or programmatic changes.

During 2001, 119 workers completed RCRA Personnel Training, and 529 workers completed Waste Generation Overview. Of the 538 workers who received credit for RCRA Refresher Training during 2001, 439 met this requirement through completing Hazardous Waste Operations (HAZWOPER) Refresher for Treatment, Storage, and Disposal Facility Workers, a course that includes the RCRA Refresher as part of its 8-hour requirement.

In response to a new Laboratory requirement, the Environment, Safety, and Health Training Group (ESH-13) developed Waste Generation Overview Refresher, a Web-based course, in 2001. Laboratory waste generators are required to take this course every three years. In 2001, 1,015 Laboratory waste generators received credit for this course.

ESH-13 updated the following RCRA courses during 2001:

- RCRA Refresher Training
- HAZWOPER: Refresher for Environmental Restoration Workers

- HAZWOPER: Refresher for Treatment, Storage, and Disposal Facility Workers
- Waste Management Coordinator Requirements

l. Hazardous Waste Report. The Hazardous Waste Report (HWR) covers hazardous and mixed waste generation, treatment, and storage activities performed at LANL during calendar year 2001 as required by RCRA, under 40 CFR 264.41 - Biennial Report. In 2001, the Laboratory generated about 3.5 million kg of RCRA hazardous waste, 3.4 million kg of which were generated by the ER Project. The waste is recorded for over 20,000 waste movements, or treatment or storage actions, resulting in over 900 Waste Generation and Management forms in the HWR. The entire report is available on the ESH-19 home page at www.esh.lanl.gov/~esh19.

m. Hazardous and Solid Waste Amendments Compliance Activities. In 2001, the ER Project remained in compliance with Module VIII of the RCRA permit. The ER Project originally identified 2,124 PRSs, consisting of 1,099 PRSs administered by NMED and 1,025 PRSs administered by DOE. By the end of 2001, only 839 discrete PRSs remain. Approximately 604 units have been approved for NFA, 139 units have been removed from the Laboratory's Hazardous Waste Facility Permit, and 17 units proposed for NFA in previous permit modification requests are pending NMED approval.

Of the 139 total PRSs removed from the permit, 37 were removed in 2001. Additionally, in 2001, we identified two new PRS, proposed 40 additional PRSs to the NMED for NFA, and provided NMED with supplemental information for 2 of the 17 PRSs pending approval.

In 2001, the LANL ER Project HSWA compliance activities included remedial site assessments and site cleanups. The assessment portion of the ER Project included submitting 2 RCRA Facility Investigation (RFI) reports to NMED and RFI fieldwork on 15 sites. The ER Project anticipates that the corrective action process for all PRSs will be complete by 2013. Based on the watershed approach, future work will focus on PRSs in the Los Alamos town site at the head of Los Alamos, Pueblo, Guaje, Rendija, Barranca, Bayo, and DP Canyons and work down each canyon to the Rio Grande. Work will then continue southward, watershed by

watershed, until we finish work on PRSs in all eight watersheds.

2. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, mandates actions for certain releases of hazardous substances into the environment. The Laboratory is not listed on the EPA's National Priority List, but the ER Project follows some CERCLA guidelines for remediating Laboratory sites that contain certain hazardous substances not covered by RCRA and/or that may not be included in Module VIII of the Laboratory's Hazardous Waste Facility Permit. DOE fulfills its responsibilities as both a natural resource trustee and lead response agency for ER Project activities at the Laboratory.

DOE's policy is to consider CERCLA Natural Resource Damage Assessment (NRDA) issues and, when appropriate, resolve them with other natural resource trustees as part of the ER Project remedy selection process. ER Project cleanup considers integrated resource management activities (e.g., biological resource management, watershed management, and groundwater protection) at the Laboratory. As ER Project cleanup activities progress, natural resource trustees (i.e., Department of Interior, Department of Agriculture Forest Service, Cochiti Pueblo, Jemez Pueblo, San Ildefonso Pueblo, Santa Clara Pueblo, and the State of New Mexico) are invited to participate in the process. DOE initiated its dialogue with the natural resource trustees on ER Project activities in 1997.

3. Emergency Planning and Community Right-to-Know Act

a. Introduction. The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order (EO) 12856.

b. Compliance Activities. In 2001, the Laboratory submitted two annual reports to fulfill its requirements under EPCRA, as shown on Table 2-4 and described below.

Emergency Planning Notification. Title III, Sections 302–303, of EPCRA requires the prepara-

tion of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees of any changes at the Laboratory that might affect the local emergency plan or if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2001.

Emergency Release Notification. Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals over specified reporting quantities into the environment. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. No leaks, spills, or other releases of specific chemicals into the environment that required EPCRA reporting occurred during 2001.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311–312, of EPCRA requires facilities to provide an annual inventory of the quantity and location of hazardous chemicals present at the facility above specified thresholds; the inventory includes the material safety data sheet for each chemical. The Laboratory submitted a report to the state emergency response commission and the Los Alamos County Fire and Police Departments listing 56 chemicals and explosives at the Laboratory that exceeded threshold limits during 2001.

Toxic Release Inventory Reporting. EO 12856 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases of listed toxic chemicals that exceed activity thresholds. Starting with reporting year 2000, new and lower chemical activity thresholds are in place for certain persistent, bioaccumulative, and toxic (PBT) chemicals and chemical categories. The thresholds for PBTs range from 0.1 gram to 100 pounds. Until this change went into effect, the highest threshold was 10,000 pounds. LANL exceeded one threshold in 2001 and therefore was required to report the use and releases. The reported material was lead, with a threshold quantity of 100 pounds established for 2001. The following releases of lead were reported: 5.2 pounds of air emissions, less than 1 pound of water releases, 3,799 pounds of on-site land releases from the shooting range, and approximately 7,800 pounds of lead waste shipped off-site for disposal.

2. Compliance Summary

Table 2-4. Compliance with Emergency Planning and Community Right-to-Know Act during 2001

Statute	Brief Description	Compliance
EPCRA Sections 302-303 Planning Notification	Requires emergency planning notification to state and local emergency planning committees.	LANL sent notification to appropriate agencies (July 30, 1999) informing officials of the presence of hazardous materials in excess of specific threshold planning quantities and of the current facility emergency coordinator. An additional update adding sodium cyanide to the list was provided in 2000.
EPCRA Section 304 Release Notification	Requires reporting of releases of certain hazardous substances over specified thresholds to state and local emergency planning committees and to the National Response Center.	There were no leaks, spills, or other releases of chemicals into the environment that required EPCRA Section 304 reporting during 2001.
EPCRA Sections 311-312 MSDSs and Chemical Inventories	Requires facilities to provide appropriate emergency response personnel with an annual inventory and other specific information for any hazardous materials present at the facility over specified thresholds.	The presence of 56 hazardous materials over specified quantities in 2001 required submittal of a hazardous chemical inventory to the state emergency response commission and the Los Alamos County Fire and Police Department.
EPCRA Section 313 Annual Releases	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds.	Threshold quantities for lead were exceeded in 2001 requiring submittal of a Toxic Chemical Release Inventory Reporting Form to the EPA and the state emergency response commission.

4. Emergency Planning under DOE Order 151.1

The Laboratory's Emergency Management Plan is a document that describes the entire process of planning, responding to, and mitigating the potential consequences of an emergency. The most recent revision of the plan, incorporating DOE Order 151.1A, will be published in March 2002. As a result of the Cerro Grande fire, the need for a new Emergency Operations Center was identified. Ground was broken for a new Joint LANL/Los Alamos County Emergency Operations Center (EOC) with enhanced communications, space for multiple agencies, and significantly improved support capabilities. The facility will also house a County Police/Fire/911 Dispatch Center. The new EOC has a scheduled completion date of fall 2003. In accordance with DOE Order 151.1A, it remains Laboratory policy to develop and maintain an

emergency management system that includes emergency planning, emergency preparedness, and effective response capabilities for responding to and mitigating the consequences of any emergency. In CY 2001, 879 employees received training as a result of Emergency Management Plan requirements and the Emergency Management and Response organization's internal training program.

5. Toxic Substances Control Act

Because the Laboratory's activities are research and development and do not involve making chemicals to sell, the PCB regulations (40 CFR 761) have been the Laboratory's main concern under the TSCA. The PCB regulations govern substances including but not limited to dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soils, and materials contaminated by spills.

2. Compliance Summary

During 2001, the Laboratory had 46 off-site shipments of PCB waste. The quantities of waste disposed include 276 kg capacitors, 25 kg laboratory waste, 1360 kg PCB-contaminated liquids, and 4037 kg fluorescent light ballasts. Approximately 15,240 kg PCB-contaminated soil was shipped off-site. The Laboratory manages all wastes in accordance with 40 CFR 761 manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and treatment facilities. Light ballasts are shipped off-site for recycling. The primary compliance document related to 40 CFR 761.180 is the annual PCB report that the Laboratory submits to EPA, Region 6.

The Laboratory disposes of nonliquid wastes containing PCB and contaminated with radioactive constituents at its TSCA-authorized landfill located at TA-54, Area G. Radioactively contaminated PCB liquid wastes are stored at the TA-54, Area L, TSCA-authorized storage facility. Some of these items with no path forward have exceeded TSCA's one-year storage limitation and are covered under the Final Rule for the Disposal of PCB, dated August 28, 1998.

The five-year letter of authorization to use Area G for PCB disposal expired in July 2001, and EPA granted an extension to LANL for continued use of Area G during the submittal and review process. LANL submitted a renewal request to EPA Region 6 January 5, 2001. An EPA Region 6 representative conducted a site visit of Areas G and L in February 2001. The Laboratory expects EPA's decision on reauthorization in the first half of 2002.

6. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides, with requirements for registration, labeling, packaging, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture (NMDA) has been granted the primary responsibility for pesticide enforcement under the FIFRA. The New Mexico Pesticide Control Act regulates private and public applicators, commercial and noncommercial applicators, pest management consultants, pesticide dealers, pesticide manufacturers, and all activities relating to the distribution and use of pesticides.

For the Laboratory, these regulations apply to the licensing and certification of pesticide applicators, record keeping, pesticide application, equipment inspection, pesticide storage, and disposal of pesticides.

NMDA did not conduct an inspection of the Laboratory's pesticide application program in 2001. However, DOE's Los Alamos Area Office (LAAO) did conduct an assessment of the program in 2001, and Johnson Controls Northern New Mexico (JCNNM) received high marks on their program implementation.

Amount of Pesticides Used during 2001:

VELPAR L (herbicide)	66 gal.
CONFRONT (herbicide)	336 oz
ROUNDUP (herbicide)	1 gal.
2-4-D Amine (herbicide)	4 gal.
PT110 PYRETHRIN (insecticide)	26 oz
TEMPO (insecticide)	2,098 g
DURSBAN (insecticide)	1 oz
STINGER (wasp freeze)	79 oz

7. Clean Air Act (CAA)

NMED or the EPA regulates Laboratory operations and its air emissions. The Air Quality Group's QA Project Plan for the Operating Permit Project, <http://www.lanl.gov/orgs/rres/maq/QA.htm>, presents a complete description of air quality requirements applicable to the Laboratory. A summary of the major aspects of the Laboratory's air quality compliance program is presented below.

a. New Mexico Air Quality Control Act. In December 1995, LANL submitted to NMED an operating permit application as required under Title V of the Clean Air Act (CAA) and Title 20 of the New Mexico Administrative Code, Chapter 2, Part 70—Operating Permits (20 NMAC 2.70). NMED has not yet issued an operating permit. When issued, the permit will specify the operational terms and limitations imposed on LANL to continue to ensure that all federal and state air quality standards are being met. In the interim, LANL continues to operate under the provisions of source-specific permits and to comply with applicable sections of the state and federal air quality regulations.

2. Compliance Summary

LANL is a major source under the Operating Permit Program based on the potential to emit regulated air pollutants. Specifically, LANL is a major source of nitrogen oxides (NO_x) emitted primarily from the TA-3 steam plant boilers. In 2001, LANL continued to implement a project to install flue gas recirculation (FGR) equipment on the boilers at TA-3 to reduce the NO_x emissions by approximately 70%. The FGR equipment is expected to be operational in 2002. Once fully operational, LANL will perform source tests to determine the beneficial effects of the equipment in reducing NO_x .

LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to revise the operating permit application, to apply for construction permits, or to submit notifications to NMED (20 NMAC 2.72). During 2001, the Laboratory performed approximately 250 air quality reviews. Two of the reviewed projects required permitting actions. Four other sources/activities, including natural-gas-fired boilers, hot water heaters, and burners along with gasoline and diesel-powered generators, were exempt from construction permitting but required written notification to NMED. As part of the Operating Permit Program, NMED collects annual fees (20 NMAC 2.71) from sources that are required to obtain an operating permit. For LANL, the fees are based on the allowable emissions from activities and operations as reported in the operating permit application. LANL's fees for 2001 were \$12,761.25.

LANL reports emissions for the following industrial-type sources: multiple boilers, a water pump, and an asphalt production facility. Table 2-5 shows LANL's calculated air pollutant emissions as reported to NMED for the 2001 emissions inventory (20 NMAC 2.73). LANL's combustion units were the primary point sources of criteria pollutants (NO_x , sulfur oxides [SO_x], particulate matter [PM], and carbon monoxide [CO] emissions). Of all combustion units, the TA-3 steam plant was the largest source of criteria pollutants. In addition to industrial-type sources, LANL reports emissions from a paper shredder, three degreasers, a rock crusher, three air curtain destructors, and from permitted beryllium activities. Smaller sources of air pollutant emissions, such as nonregulated boilers, emergency generators, space heaters, etc., are located throughout LANL. NMED considers these smaller sources insignificant. Therefore, these sources are not required to be and were not included in the annual emissions inventory.

LANL calculates air emissions using emission factors from source tests, manufacturer data, and EPA documentation. Calculated emissions for industrial sources are based on actual production rates or fuel consumption rates. These industrial-type sources operated primarily on natural gas. The steam plant boilers at TA-3 and TA-21 are capable of burning diesel as a backup.

Figure 2-1 provides a comparison among recent emissions inventories reported to NMED. SO_x emissions returned to normal values after a significant increase in 2000. This change is attributable to the steam plant burning only two-thirds the fuel oil in 2001 that it burned in 2000 (120,000 gallons versus 180,000). The rock crusher was not operated in 2001; therefore, there were no PM emissions from the crushing activities and no combustion products from the rock crusher diesel-fired engine. An assessment of the ambient impacts of air pollutant emissions, presented in the Site-Wide Environmental Impact Statement (SWEIS) Yearbook for 2001, indicates that all emissions are less than the amounts evaluated in the SWEIS. Therefore, no adverse air quality impacts are expected from these emissions.

R&D activities were the primary source of VOC and hazardous air pollutant (HAP) emissions. Detailed analysis of chemical tracking and procurement records indicates that LANL procured approximately 19 tons of VOCs. For a conservative estimate of air emissions, the total quantity of procured VOCs were assumed to be emitted along with VOC emissions calculated for industrial-type sources. The HAP emissions reported from R&D activities generally reflect the quantities procured during the calendar year. In a few cases, procurement values and operational processes were evaluated in more detail so we could report actual emissions in place of the procured value. The total quantity of HAP emissions reported for the year 2001 was 7.4 tons, similar to the 6.5 tons reported in 2000.

Construction Permits. LANL currently operates under the air permits listed in Table 2-1. Table 2-6 summarizes allowable emissions from 20 NMAC 2.72 Construction Permits. In 2001, the Laboratory submitted two Notice of Intent (NOI) applications under 20 NMAC 2.73. The first addressed the installation of three air curtain destructors to burn slash from fire mitigation activities on LANL property. The NMED determined that these sources were applicable under 20 NMAC 2.60 Open Burning and issued an open burn permit on June 20, 2001. The second NOI addressed the installation of two boilers

2. Compliance Summary

Table 2-5. Calculated Actual Emissions for Regulated Pollutants (Tons) Reported to NMED

Emission Units	Pollutants					
	PM	CO	NO _x	SO _x	VOC	HAP
Asphalt Plant	0.09	0.52	0.03	0.006	0.01	NA
TA-3 Steam Plant	3.5	18	74	0.72	2.5	NA
TA-16 Boilers	0.05	0.26	0.26	0.004	0.04	NA
TA-21 Steam Plant	0.14	1.55	1.85	0.01	0.1	NA
Water Pump	0.06	3.01	9.41	0.004	0.19	NA
TA-48 Boilers	0.11	1.26	1.5	0.01	0.07	NA
TA-53 Boilers	0.1	1.0	1.2	0.008	0.06	NA
TA-55 Boilers	0.24	1.65	2.88	0.014	0.1	NA
TA-59 Boilers	0.06	0.76	0.9	0.006	0.04	NA
Air Curtain Destructors	1.15	0.99	1.88	0.055	2.36	NA
Degreasers	NA	NA	NA	NA	0.01	NA
Paper Shredder	0.0007	NA	NA	NA	NA	NA
Rock Crusher	0	0	0	0	0	NA
R & D	NA	NA	NA	NA	18.6	7.4
Total	5.5	29	94	0.8	24	7.4

NA = not applicable.

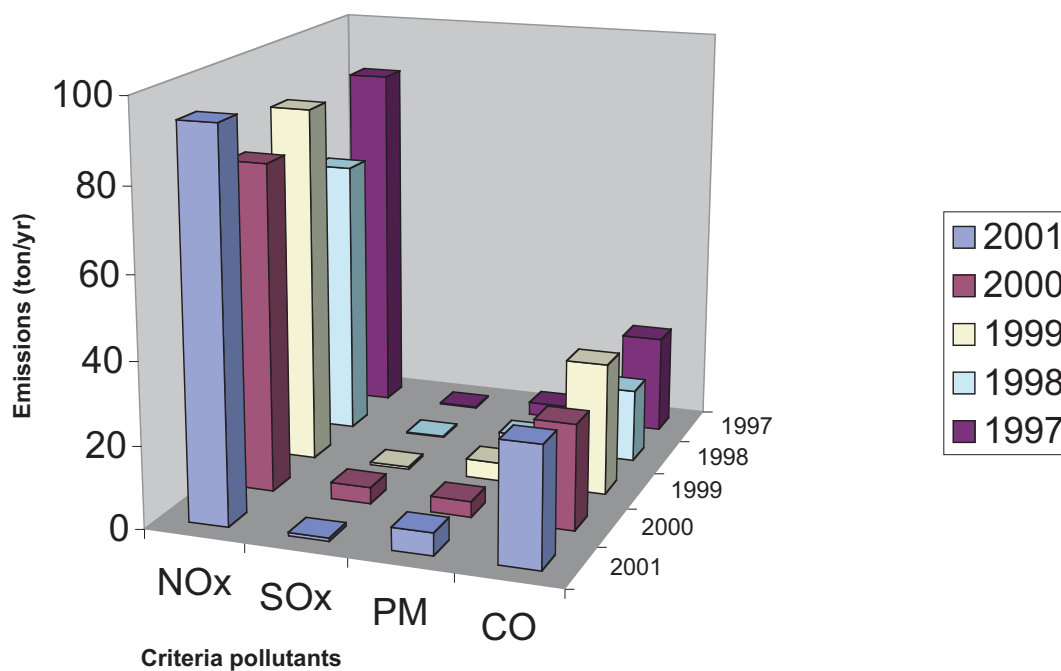


Figure 2-1. Criteria pollutant emissions from LANL.

2. Compliance Summary

Table 2-6. Allowable Air Emissions (20 NMAC 2.72)

Source	Condition	Regulated Pollutant	Allowable Emissions
Beryllium Machining at TA-3-39	NA	Beryllium	0.008 lb/yr
Beryllium Machining at TA-3-102	NA	Beryllium	4.0E-06 lb/hr
Beryllium Machining at TA-3-141	NA	Beryllium	0.00014 lb/yr
Beryllium Machining at TA-35-213	NA	Beryllium	4.0E-07 lb/hr
Beryllium Activities at TA-55-4	Machining	Beryllium	0.0004 lb/yr
Beryllium Activities at TA-55-4	Machining	Beryllium	3.0E-06 lb/hr
Beryllium Activities at TA-55-4	Machining	Beryllium	0.0008 lb/yr
Beryllium Activities at TA-55-4	Machining	Beryllium	4.0E-07 lb/hr
Beryllium Activities at TA-55-4	Machining	Beryllium	0.0066 lb/yr
Beryllium Activities at TA-55-4	Machining	Beryllium	2.6E-04 lb/24-hr
Beryllium Activities at TA-55-4	Machining	Aluminum	0.0066 lb/yr
Beryllium Activities at TA-55-4	Machining	Aluminum	2.6E-04 lb/24-hr
Beryllium Activities at TA-55-4	Foundry	Beryllium	1.9E-06 lb/yr
Beryllium Activities at TA-55-4	Foundry	Beryllium	7.7E-08 lb/24-hr
Beryllium Activities at TA-55-4	Foundry	Aluminum	1.9E-06 lb/yr
Beryllium Activities at TA-55-4	Foundry	Aluminum	7.7E-08 lb/24-hr
Beryllium Activities at TA-55-4	Combined	Beryllium	0.0066 lb/yr
Beryllium Activities at TA-55-4	Combined	Beryllium	2.6E-04 lb/24-hr
Beryllium Activities at TA-55-4	Combined	Aluminum	0.0066 lb/yr
Beryllium Activities at TA-55-4	Combined	Aluminum	2.6E-04 lb/24-hr
Rock Crusher	NA	Particulate Matter	Limited ^a
Rock Crusher	NA	Nitrogen Dioxide	6.4 tons/yr
Rock Crusher	NA	Nitrogen Dioxide	6.2 lb/hr
Rock Crusher	NA	Carbon Monoxide	1.4 tons/yr
Rock Crusher	NA	Carbon Monoxide	1.3 lb/hr
Rock Crusher	NA	Volatile Organic Compounds	0.5 tons/yr
Rock Crusher	NA	Volatile Organic Compounds	0.5 lb/hr
Rock Crusher	NA	Sulfur Dioxide	0.4 tons/yr
Rock Crusher	NA	Sulfur Dioxide	0.4 lb/hr
TA-3 Steam Plant	Per Boiler Burning Natural Gas ^b	Particulate Matter	1.4 lb/hr
TA-3 Steam Plant	Per Boiler Burning Natural Gas ^b	Nitrogen Oxides	9.0 lb/hr
TA-3 Steam Plant	Per Boiler Burning Natural Gas ^b	Carbon Monoxide	7.4 lb/hr
TA-3 Steam Plant	Per Boiler Burning Natural Gas ^b	Volatile Organic Compounds	1.0 lb/hr
TA-3 Steam Plant	Per Boiler Burning Natural Gas ^b	Sulfur Oxides	2.6 lb/hr
TA-3 Steam Plant	Per Boiler Burning Fuel Oil ^b	Particulate Matter	2.7 lb/hr
TA-3 Steam Plant	Per Boiler Burning Fuel Oil ^b	Nitrogen Oxides	9.9 lb/hr
TA-3 Steam Plant	Per Boiler Burning Fuel Oil ^b	Carbon Monoxide	6.8 lb/hr
TA-3 Steam Plant	Per Boiler Burning Fuel Oil ^b	Volatile Organic Compounds	0.3 lb/hr
TA-3 Steam Plant	Per Boiler Burning Fuel Oil ^b	Sulfur Oxides	68.7 lb/hr
TA-3 Steam Plant	Combined Fuel Use for all Three Boilers	Particulate Matter	15.7 tons/yr
TA-3 Steam Plant	Combined Fuel Use for all Three Boilers	Nitrogen Oxides	99.6 tons/yr
TA-3 Steam Plant	Combined Fuel Use for all Three Boilers	Carbon Monoxide	81.3 tons/yr
TA-3 Steam Plant	Combined Fuel Use for all Three Boilers	Volatile Organic Compounds	11.1 tons/yr
TA-3 Steam Plant	Combined Fuel Use for all Three Boilers	Sulfur Oxides	36.9 tons/yr

^aFugitive particulate matter emissions from transfer points, belt conveyors, screens, feed bins, and from stockpiles shall not exhibit greater than 10% opacity. Fugitive particulate matter emissions from the rock crusher shall not exhibit greater than 15% opacity. Opacity is the degree to which emissions reduce the transmission of light and obscure the view of a background object.

^bThere are three boilers at the TA-3 Steam Plant.

at TA-55. The NMED determined that these sources did not require a construction permit.

Open Burning. LANL has an open burning permit (20 NMAC 2.60) for operational burns conducted for research projects. All operational burns for 2001 were conducted within the terms specified in the permit.

In addition to operational burns, the Laboratory also conducted prescribed burning to assist with fire mitigation activities resulting from the Cerro Grande fire. On June 20, 2001, LANL was granted an open burn permit to operate three air curtain destructors (ACDs) within the Laboratory boundaries. These special units were chosen instead of traditional open air burning because of the ACD's ability to operate with very little visible smoke emissions. These ACDs were installed and operated for several months on Engineering Sciences and Applications (ESA) property in TA-16. During the course of these operations, the Laboratory burned over 1,200 tons of slash from fire mitigation activities in 2001. Operations are expected to continue throughout 2002. In December 2001, the Laboratory conducted its initial compliance test for opacity for each of these units. All three met the opacity limitations outlined in 40 CFR 60, Subpart CCCC.

Asbestos. The National Emission Standard for Hazardous Air Pollutants for Asbestos (Asbestos NESHAP, 40 CFR 61 Subpart M) requires that LANL provide advance notice to NMED for large renovation jobs involving asbestos and for all demolition projects. The Asbestos NESHAP further requires that all activities involving asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the Asbestos NESHAP. As in 2000, several projects in 2001 resulted from fire recovery efforts such as renovating or demolishing buildings damaged during the Cerro Grande fire. In addition to fire recovery efforts, other activities included four large renovation jobs and demolition projects for which NMED received advance notice. These projects, combined with fire recovery activities, generated a total 2070 m³ of asbestos waste, which was not radioactively contaminated. This significant increase in asbestos waste (only 302 m³ in 2000) was the result of cleanup activities in support of the Cerro Grande

fire recovery. Specifically, over 1800 m³ of asbestos waste came from recovery efforts at TA-40. All asbestos wastes were properly packaged and disposed at approved landfills.

To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly. In addition, NMED's two inspections during the year identified no violations. The Air Quality Group's QA Project Plan for the Asbestos Report Project is available at <http://www.esh.lanl.gov/~AirQuality/QA.htm> on the World Wide Web.

Degreasers. The solvent cleaning NESHAP (40CFR 63, Subpart T) requires that all solvent cleaning machines containing any of the six listed halogenated solvents be registered with NMED. In late 2000, the Laboratory removed the solvent from a Cold Ultrasonic Bath Degreaser at TA-46. As such, the Laboratory currently operates two regulated solvent cleaning machines registered with NMED.

b. Federal Clean Air Act. The State of New Mexico has adopted all of the federal air quality requirements, with three exceptions: the Stratospheric Ozone Protection (40 CFR 82, Subpart F), the NESHAP for Radionuclides (40 CFR 61, Subpart H), and the Risk Management Program (40 CFR 68).

Ozone-Depleting Substances. Title VI of the CAA contains specific sections establishing regulations and requirements for ozone-depleting substances (ODS) such as halons and refrigerants. The sections applicable to the Laboratory include Section 608, National Recycling and Emission Reduction Program, and Section 609, Servicing of Motor Vehicle Air Conditioners. Section 608 prohibits individuals from knowingly venting ODS into the atmosphere during maintenance, repair, service, or disposal of halon fire suppression systems and air conditioning or refrigeration equipment. All technicians who work on refrigerant systems have to be EPA certified and use certified recovery equipment. The Laboratory is required to maintain records on all work involving refrigerants as well as the purchase, usage, and disposal of refrigerants. All work must be performed in accordance with EPA requirements and Laboratory standards. The Laboratory's standards for refrigeration work are covered under Criterion 408, "EPA Compliance for Refrigeration Equipment," of the Operations and Maintenance manual. Section 609 includes standards and requirements for recycling equipment used to service motor vehicle air conditioners and for training

2. Compliance Summary

and certification of maintenance and repair technicians. LANL contracts with JCNNM and other vendors to maintain, service, repair, and dispose of halon fire suppression systems and air conditioning and refrigeration equipment. LANL contracts automotive repair work, including motor vehicle air-conditioning work, to JCNNM and to qualified local automotive repair shops.

Radionuclides. Under the National Emission Standard for Hazardous Air Pollutants for Radionuclides (Rad NESHAP), EPA limits the effective dose equivalent (EDE) to any member of the public from radioactive airborne releases from a DOE facility, such as LANL, to 10 mrem/yr. The 2001 EDE (as calculated using EPA-approved methods) was 1.8 mrem. The location of the highest dose was at East Gate. The principal contributor to the dose was operations from the Los Alamos Neutron Science Center (LANSCE). The Air Quality Group's QA Project Plan for the Rad NESHAP Compliance Project is available at <http://www.lanl.gov/orgs/rres/maq/QA.htm> on the World Wide Web.

LANL reviews plans for new and modified projects, activities, and operations to identify the need for emissions monitoring or prior approval from EPA. During 2001, approximately 80 reviews involved the evaluation of air quality requirements associated with the use of radioactive materials. None of these projects required EPA prior approval.

During 2002, independent auditors will conduct the third independent audit of the Laboratory's Rad-NESHAP program. This audit will begin in mid-2002 and will evaluate the Laboratory's compliance for calendar year 2001.

Risk Management Program. The 1990 Clean Air Act Amendments (1990 CAA) included Section 112(r), Prevention of Accidental Releases. Section 112(r) required the EPA to establish a risk management program (RMP) to prevent accidental releases of flammable and toxic substances to the environment and to minimize the consequences of a release. The 112(r) program provides lists of toxic and flammable substances with their associated threshold quantities (TQ). Any process or storage facility that uses any listed substance in quantities exceeding its TQ is subject to EPA's RMP. Under the 112(r) program, threshold determinations are based on the quantity of substance present at a particular location or in a particular process at any point in time (i.e., what is the potential for release during an accident). Threshold

determinations are not based on cumulative usage. EPA established the requirements for the RMP in 40 CFR 68. Facilities that are subject to the RMP were required to register with EPA and submit a facility specific risk management plan by June 21, 1999. LANL has not exceeded any TQ between the effective date (June 21, 1999) and the present date. Therefore, LANL is not subject to the RMP and is not required to register with EPA. LANL will continue to evaluate chemical procurements, new sources, and processes containing regulated substances to determine any change in the applicability status of the RMP.

8. Clean Water Act

a. National Pollutant Discharge Elimination System Outfall Program. The primary goal of the Clean Water Act (CWA) (33 U.S.C. 1251 et seq.) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for National Pollutant Discharge Elimination System (NPDES) permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that an effluent must meet before it is discharged. Although most of the Laboratory's effluent is discharged to normally dry arroyos, the Laboratory is required to meet effluent limitations under the NPDES permit program.

UC and DOE are co-permittees of the NPDES permit covering Laboratory operations. EPA Region 6 in Dallas, Texas, issues and enforces the permit. However, NMED certifies the EPA-issued permit and performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

The Laboratory's NPDES Permit, No. NM0028355, expired October 31, 1998, but was administratively continued by EPA until a new permit was issued. As required by the NPDES regulations, on May 4, 1998, 180 days before permit expiration, the Laboratory submitted an application to EPA for renewal of the NPDES permit. On December 29, 2000, the EPA issued the Public Notice of Final Permit Decision for NPDES Permit No. NM0028355. The new NPDES Permit became effective on February 1, 2001, and contains 21 permitted outfalls.

No NPDES outfalls were deleted in 2001. Long-term objectives of the NPDES Outfall Reduction Program will require that outfall owners evaluate

2. Compliance Summary

outfalls for continued operation and that new construction designs and modifications to existing facilities provide for reduced or no-flow effluent discharge systems.

Under the Laboratory's NPDES outfall permit, samples for effluent quality limits are collected for analysis weekly, monthly, and quarterly depending on the outfall category. The Laboratory also collects water quality samples for analysis annually at all outfalls. The Laboratory reports results to EPA and NMED at the end of the monitoring period for each respective outfall category. During CY 2001, four of the 1,085 samples collected from the industrial outfalls exceeded effluent limits (Table 2-7). No effluent limit exceedances occurred in the 134 samples collected from the Sanitary Wastewater System (SWS) Facility Outfall 13S. See Table A-4 for a summary of these outfalls and a listing of the permit's monitoring requirements.

Table 2-7 presents the exceedances of the water quality parameters for sanitary and industrial outfalls during 2001. The following is a summary of the corrective actions the Laboratory took during 2001 to address permit noncompliances.

TA-3 Power Plant (NPDES Outfall 001). On February 27, 2001, the total suspended solids (TSS) concentration exceeded the NPDES average and maximum permit limits at NPDES Outfall 001. On the

day of the exceedance, operators were flushing out the cooling towers so that they could inspect the underground cooling lines. A new cooling tower was built in the summer of 2000 with fiberglass members that could explain fibers and aggregates in the effluent. In a repeat analytical sample collected on March 7, 2001, a TSS value of 3.5 mg/l documented that the effluent was back into compliance with the NPDES permit limits. The primary and secondary environmental tanks were inspected during the May 2001 shutdown; however, the TSS source was not identified. Additionally, further analysis of the compliance sample determined the primary constituent in the sample to be silica. The operating group completed additional corrective actions including construction of an additional tank to separate out the waste streams, boiler blow-down, and the demineralizer.

TA-16, High-Explosive Waste Treatment Facility (NPDES Outfall 05A055). On March 9, 2001, the pH result exceeded the NPDES maximum permit limit at NPDES Outfall 05A055. Potential sources of elevated pH at this outfall include soaps from dishwashers used in the high-explosives analytical laboratories or the change out of carbon filters at the High-Explosive Wastewater Treatment Facility (HEWTF). Site representatives were monitoring the pH of the effluent tank using pH strips that might not have been accurate in the presence of detergents. Site

Table 2-7. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality and Water Quality Parameters at Industrial Outfalls: Exceedances during 2001

EPA ID	Outfall Type	Technical Area	Date	Parameter	Results/Limits	Units
February						
001	Industrial	TA-3-22	2/27/01	TSS (daily max)	232/100	mg/L
001	Industrial	TA-3-22	2/1/01–2/28/01	TSS (daily avg)	232/30	mg/L
March						
05A055	Industrial	TA-16-1508	3/9/01	pH (daily max)	9.8/9.0	s.u.
September						
03A185	Industrial	TA-15-312	9-17-01	Se (daily max)*WQP	0.008/0.005	mg/L

TSS = total suspended solids.
WQP = water quality parameters.

2. Compliance Summary

representatives will analyze operational samples before discharge for pH using an electrode pH meter instead pH strips. The operating group will not discharge if the effluent is outside of the pH range 6.0–9.0 standard units. Additionally, the operating group added CO² for pH adjustment in May of 2001.

TA-15, DARHT Cooling Tower (NPDES Outfall 03A185). On September 17, 2001, the total selenium (Se) concentration exceeded the NPDES maximum permit limit at Outfall 03A185. A new treatment chemical containing low levels of total selenium was in use at this cooling tower several months before this compliance sample was collected. A sample of concentrated (full strength) treatment chemical submitted for total selenium analysis showed some selenium was present. When used at the recommended concentration of 40 ppm, the total selenium result should be well below the permit limit of 0.005 mg/L. The use of the new treatment chemical was suspended. In an additional compliance sample collected on October 30, 2001, the nondetect for total selenium documented that the discharge was back in compliance with the NPDES permit on this date.

b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program. In July 1997, the Laboratory requested approval from the EPA Region 6 to make a formal change in its sewage sludge disposal practices from land application under 40 CFR Part 503 regulations to landfill disposal as a 50–499 ppm PCB-contaminated TSCA waste, as authorized under 40 CFR 761. This change was necessary because of the repeated detection of low-level PCBs (less than 5 ppm) in the SWS Facility's sewage sludge. The EPA approved the Laboratory's request in September 1997.

Following this change, the Laboratory began an investigation to determine the source of the PCBs found in the SWS Facility's sludge. The investigation's findings led the Laboratory to believe that the PCBs appearing at the SWS Facility might have originated from the remnants of old PCB spills in sewer lines. Subsequently, the Laboratory undertook a program of testing and cleaning sewer lines. Based upon the analytical data obtained from testing sludge, grit, and screenings, the Laboratory believed that it could begin to safely dispose of the sanitary treatment solids as a non-TSCA waste. In September 2000, the Laboratory notified the EPA Region 6 that it intended to change its disposal practice for sewage sludge, grit, and screenings to disposal as a non-TSCA waste (total

PCB concentration less than 50 ppm), as authorized under 40 CFR 761.20(a)(4). After September 2000, the Laboratory began disposing of all SWS Facility sludge with less than 50 ppm PCBs as a New Mexico Special Waste.

During 2001, the SWS Facility generated approximately 25 dry tons (49,923 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

c. National Pollutant Discharge Elimination System Permit Compliance Evaluation Inspection. The EPA and the NMED did not conduct a NPDES Outfall Compliance Evaluation Inspection during 2001 (see Table 2-3).

d. National Pollutant Discharge Elimination System Storm Water Program. The NPDES permit program regulates storm water discharges from identified industrial and construction activities. During 2001, the Laboratory had 11 active NPDES permits for its storm water discharges (see Table 2-1). Under the EPA's NPDES Storm Water Multi-Sector General Permit for Industrial Discharges, the Laboratory is covered by one overall active permit. Under the EPA Region 6 NPDES Storm Water Construction permit, 10 Laboratory projects were permitted and active: DARHT Facility Construction Project, Guaje Well Improvements Project, the Fire Protection Improvements Project, the Norton Power Line Project, the Strategic Computing Complex (SCC) Project, the TA-9 to TA-15 Gas Pipeline Replacement Project, the Flood Mitigation and Fire Recovery Project, the Nuclear Materials Safeguards and Security Upgrades (NMSSUP) Project, TA-3 Revitalization, and TA-55 Fireloop Construction.

UC and DOE are co-permittees under the NPDES Multi-Sector General Permit (MSGP-2000) for the Laboratory. The MSGP-2000 regulates storm water discharges from the following Laboratory industrial activities:

- Sector K—hazardous waste treatment, storage, and disposal facilities including those that are operating under interim status or a permit under Subtitle C of RCRA (this category includes SWMUs);
- Sector L—landfills, land application sites, and open dumps including those that are subject to regulation under Subtitle D of RCRA;

- Sector O—steam electric power generating facilities;
- Sector D—asphalt paving operations;
- Sector N—scrap recycling and waste recycling facilities;
- Sector P—land transportation and warehousing;
- Sector F—primary metals;
- Sector AA—fabricated metal products; and
- Sector C—chemical and allied products manufacturing activities.

Since 1992, the MSGP-2000 is the third general permit the EPA has published to regulate storm water discharges from industrial activities at the Laboratory. This permit expires October 30, 2005. As with the 1992 Baseline General Permit and 1995 Multi-Sector General Permit, the MSGP-2000 requires the development and implementation of a Storm Water Pollution Prevention Plan, which includes installing, inspecting, and maintaining Best Management Practices (BMPs) to reduce the potential for pollutants to migrate into watercourses. During 2001, the Laboratory maintained and implemented 20 Storm Water Pollution Prevention Plans for its industrial activities.

The Multi-Sector General Permit also requires monitoring of the storm water discharges from all identified industrial activities. To meet the monitoring requirements of the MSGP-2000 and other monitoring programs, the Laboratory is operating 69 storm-water monitoring stations within the canyons entering and leaving the Laboratory. These stations collect storm event samples at the confluence of the major canyons and within certain reaches of these canyons. In addition, monitoring is conducted at sector-specific industrial facilities.

The Laboratory collected 96 storm event samples (as compared with 70 samples in 2000) during the summer of 2001 and has submitted this data to EPA and NMED in accordance with the permit's Discharge Monitoring Report (DMR) requirements. The increase, when compared with previous years, in the number of samples submitted was largely due to the Laboratory's efforts to sample and characterize storm-water runoff from Laboratory property impacted by the Cerro Grande fire. "Surface Water Data at Los Alamos National Laboratory: 2001 Water Year" (Shaull et al., 2002) reports the discharge information for 2001.

During 2001, the Laboratory's 10 active construction projects were permitted under the July 6, 1998, EPA

Region 6 NPDES General Permit for Storm Water Discharges from Construction Activities Permit. Under the Construction Regulations, all construction sites disturbing five or more acres, including those that are part of a larger plan of development collectively disturbing five or more acres, are required to have a permit. The NPDES Construction Permit regulates storm-water discharges from the construction sites. LANL, with operational control of the construction project plans and specifications, is usually co-permittee with the contractor, who has day-to-day operational control of site activities.

Like the MSGP Permit, the Construction Permit requires each construction site to develop and implement a Storm Water Pollution Prevention (SWPP) Plan. The SWPP Plans describe and ensure the implementation of practices to reduce the pollutants in storm-water discharges associated with construction activity and assure compliance with the terms and conditions of the permit. These practices include installing, inspecting, and maintaining structural and vegetative erosion and sediment controls, postconstruction storm-water management controls, and other controls to limit off-site sediment tracking and contamination of runoff with other potential pollutants. Furthermore, each Plan must describe and implement measures necessary to protect listed endangered or threatened species and critical habitat. In 2001, the Laboratory implemented and maintained 23 construction-related SWPP Plans.

To assist those involved with LANL construction projects, the Laboratory provides design comments with respect to NPDES concerns, aids in the development of SWPP Plans, and inspects the sites in accordance with NPDES Regulations. Inspections occur every 14 days for active sites, every month for inactive sites (when not under a winter waiver), and after any 0.5-in. precipitation event. The appropriate project supervisors receive inspection reports, which document the condition of the site and the site's controls and give recommendations to ensure NPDES Permit compliance.

To track the many industrial and construction sites, the associated BMPs, and the site inspections, the Laboratory has developed a GIS-based tracking system. The system maintains records of the contacts for each site and tracks

- each inspection,
- the condition of each BMP at the time of the inspection,

2. Compliance Summary

- deficiencies found,
- the date the deficiencies were corrected,
- work that is required at the site, and
- the overall status of the site.

In addition, the Laboratory maintains a spreadsheet that lists each of the permits, their holders, related permits, and the dates of their termination. General permit information for the Laboratory is accessible to the public through postings in the Laboratory's Community Involvement Office Reading Room and at the ESH-18 Web site.

e. National Pollutant Discharge Elimination System Storm Water Program Inspection. The Laboratory corrected deficiencies noted during a July 12, 1999, EPA Region 6 compliance inspection of the Laboratory's Storm Water Program. At this date, all deficiencies have been addressed.

f. Spill Prevention Control and Countermeasures Program. The Laboratory's Spill Prevention Control and Countermeasures (SPCC) Plans, as required by the CWA in accordance with 40 CFR 112, are comprehensive plans developed to meet EPA requirements that regulate water pollution from oil spills. Table 2-8 shows the SPCC Plans and tanks covered at the Laboratory for 2001. Three tanks were installed at TA-3-316 during 2001.

A spill that did not impact the navigable waters of the US or adjoining shorelines occurred within the ATLAS facility on January 8, 2001. The DOE proactively developed a Corrective Action Plan that includes making improvements in safety performance throughout the Laboratory. The Laboratory's SPCC Plans will be amended to reflect these changes in the Laboratory's potential for the discharge of oil.

g. Dredge and Fill Permit Program. Section 404 of the CWA requires the Laboratory to obtain permits from the US Corps of Engineers (COE) to perform work within perennial, intermittent, or ephemeral watercourses. Projects involving excavation or fill below the normal high-water mark must be conducted with attention to the water quality and riparian habitat preservation requirements of the Act. COE has issued a number of nationwide permits that cover specific activities. Each nationwide permit contains conditions to protect water quality. Section 401 of the CWA requires states to certify that Section 404 permits issued by COE will not prevent attainment of state-mandated stream standards. NMED

reviews Section 404/401 joint permit applications and issues separate Section 401 certification letters, which include additional permit requirements to meet state stream standards for individual projects at the Laboratory.

Because of the increased runoff from the Cerro Grande fire, a larger number of Section 404 projects were undertaken during 2001 than in pre-fire years. Many of the projects listed relate to strengthening road crossings or removing sediment that has built up behind culverted road crossings. The removal of sediment at these road crossings is required to keep water from backing up at the culverts and eroding the surface of the road.

Table 2-1 lists all of the Laboratory's Section 404/401 permits during 2001. Projects permitted include utility lines, road crossings, headwaters and isolated waters, and wetland/riparian areas.

9. Safe Drinking Water Act

a. Introduction. On September 5, 2001, DOE completed the transfer of ownership of the Los Alamos Water Supply System to Los Alamos County. Since September 1998, Los Alamos County has operated the water system under a lease agreement. Under this agreement, the Laboratory retained responsibility for operating the distribution system within the Laboratory's boundaries, whereas the county assumed full responsibility for operating the water system, including ensuring compliance with the requirements of the federal Safe Drinking Water Act (SDWA) (40 CFR 141) and the New Mexico Drinking Water Regulations (NMEIB 1995). The SDWA requires Los Alamos County to collect samples from various points in the Laboratory's, Los Alamos County's, and Bandelier National Monument's water distribution systems and from the water supply wellheads to demonstrate compliance with SDWA maximum contaminant levels (MCLs). The EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The state has adopted these standards and has included them in the New Mexico Drinking Water Regulations. The EPA has authorized NMED to administer and enforce federal drinking water regulations and standards in New Mexico.

During 2001, the Laboratory sampled all of the water supply wells in operation at the time of sampling for quality assurance purposes. The Laboratory's quality assurance drinking water program provides

Table 2.8. 2001 SPCC Plans and Tanks

SPCC Plan Name	Tanks Covered
DX	15-261, 15-324, 15-325, 15-435, 15-436, 15-473, 15-474, 36-141, 36-142 (Note: Fire destroyed 15-261 in May 2000, but the plan was not updated.)
TA-3-316	three tanks inside Building 3-316
DARHT	15-461, 15-462
TA-35-29 THOR	three tanks in basement
TA-3 Power Plant	3-26, 3-779
TA-3 Asphalt Batch Plant	3-1969 and 3-1968
TA-21 Steam Power Plant included in WCRRF and RAMROD SWPP	21-57 and 600 gal tank
included in TA-50 FMU 64 SWPP	50-183
TA-53	53-640-AST, 53-1058-AST, 53-1071A-AST, 53-1071B-AST, 53-645-AST
ATLAS	Tank outside Building 35-125

additional assurance during the transition period following transfer of the water system to Los Alamos County. The Laboratory's monitoring results are not for SDWA compliance purposes; Los Alamos County's SDWA sampling program determines SDWA compliance. This report presents the results from both the quality assurance monitoring the Laboratory conducted and the SDWA compliance monitoring Los Alamos County conducted.

In 2001, the monitoring network for Los Alamos County's SDWA compliance sampling program consisted of the following three location groups:

- (1) wellhead sampling from the water supply wells in operation at the time of sampling (Guaje wells G1A, G2A, G3A, G4A, G5A; Pajarito Mesa wells PM1, PM2, PM3, PM4, PM5; and Otowi wells O1, O4);
- (2) the 6 total trihalomethane (TTHM) sampling locations within the distribution system; and
- (3) the 41 microbiological sampling sites located throughout the Laboratory, Los Alamos County, and Bandelier National Monument.

Staff from the NMED Drinking Water Bureau performed all chemical and radiological sampling for Los Alamos County with the exception of TTHM sample collection, which JCNNM and Los Alamos

County staff conducted. The New Mexico Health Department's Scientific Laboratory Division in Albuquerque and the New Mexico State University's Soil and Water Testing Laboratory in Las Cruces received samples for analysis. The JCNNM Health and Environmental (HENV) laboratory performs microbiological sampling and analysis. NMED has certified the HENV laboratory for microbiological compliance analysis. Certification requirements include proficiency samples, maintaining an approved quality assurance/quality control program, and periodic NMED audits.

In 2001, the Laboratory's monitoring network for quality assurance sampling consisted of the following: wellhead sampling from the 12 water supply wells in operation at the time of sampling (Guaje wells G1A, G2A, G3A, G4A, G5A; Pajarito Mesa wells PM1, PM2, PM3, PM4, PM5; and Otowi wells O1, O4). Sample collection and preservation procedures and analytical methods follow the requirements specified in federal and state regulations. Laboratory staff performed chemical and radiological sampling and submitted the samples for analysis to the New Mexico Health Department's Scientific Laboratory Division in Albuquerque. ESH-18 has certified staff to perform drinking water sampling. ESH-18 maintains both

2. Compliance Summary

electronic and hard copy files of all data collected from quality assurance testing.

b. Radiochemical Analytical Results. In 2001, Los Alamos County collected drinking water samples from seven water supply wells to determine the radiological quality of the drinking water. As shown in Table 2-9, the concentrations of gross alpha and gross beta activity were less than the EPA screening levels. When gross alpha and beta activity measurements are below the screening levels, Los Alamos County does not need to perform further isotopic analyses or perform dose calculations under the SDWA program. However, it should be noted that ESH-18 also conducts comprehensive monitoring of the water supply wells for radiochemical constituents (see Table 5-20).

Neither NMED nor Los Alamos County collected radon samples for compliance purposes during 2001.

In 2001, the Laboratory collected quality assurance drinking water samples at 12 water supply wells to determine the radiological quality of the drinking water. As shown in Table 2-10, the concentrations of gross alpha and gross beta activity were less than the EPA screening levels.

c. Nonradiological Analytical Results. In 2001, Los Alamos County collected TTHM samples during each quarter from six locations in the Laboratory and Los Alamos County water distribution systems. As shown in Table 2-11, the annual average for samples in 2001 was 3.9 µg of TTHM per liter of water, less than the SDWA MCL of 80 µ/L. In 2001, Los Alamos County collected samples for nitrate/nitrite (as nitrogen) in drinking water at the 11 water supply wells in operation at the time of sampling. As shown in Table 2-12, nitrate/nitrite concentrations at all locations were less than the SDWA MCL. In 2001, Los Alamos County collected samples for VOCs at 12 water supply wells. No VOCs were detected at any of the sampling locations. In 2001, LANL also collected quality assurance samples for inorganic constituents in drinking water at the 12 water supply wells. As shown in Table 2-13, all inorganic constituents at all locations were less than the SDWA MCLs. In 2001, LANL also collected quality assurance VOC samples from the 12 water supply wells. No VOCs were detected at any of the sampling locations at concentrations greater than the analytical laboratory's sample detection limit.

d. Microbiological Analyses of Drinking Water. Each month during 2001, Los Alamos County collected an average of 46 samples from the Laboratory's, Los Alamos County's, and Bandelier

National Monument's water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the drinking water. Of the 553 samples analyzed during 2001, none indicated the presence of total or fecal coliforms. Noncoliform bacteria were present in 41 of the microbiological samples. Noncoliform bacteria are not regulated, but their repeated presence in samples may serve as an indicator of stagnation and biofilm growth in water pipes. The maximum count of noncoliform bacteria in a 2001 sample was 122 colonies per milliliter. This level is well below the EPA-recommended limit for drinking water of 500 colonies per milliliter. Table 2-14 presents a summary of the monthly analytical data.

e. Long-Term Trends. During 2001, the Los Alamos water system continued to produce high-quality drinking water that is fully compliant with state and federal drinking water standards. The water system has never incurred a violation for an SDWA-regulated chemical or radiological contaminant. During 2001, no increasing trends were evident for contaminants that the SDWA currently regulates.

f. Drinking Water Inspection. The NMED did not conduct an inspection of the drinking water system during 2001.

10. Groundwater

a. Groundwater Protection Compliance Issues. Groundwater monitoring and protection efforts at the Laboratory have evolved from programs initiated by the US Geological Survey in the 1940s to present efforts. The major regulations, orders, and policies pertaining to groundwater are described in the following paragraphs.

DOE Order 5400.1 requires the Laboratory to prepare a Groundwater Protection Management Program Plan that focuses on protection of groundwater resources in and around the Los Alamos area and ensures that all groundwater-related activities comply with the applicable federal and state regulations.

Task III of Module VIII of the RCRA Hazardous Waste Facility Permit, the HSWA Module, requires the Laboratory to collect information about the environmental setting at the facility and to collect data on groundwater contamination. Task III, Section A.1, requires the Laboratory to conduct a program to evaluate hydrogeologic conditions. Task III, Section C.1, requires the Laboratory to conduct a groundwater

2. Compliance Summary

Table 2-9. Radioactivity (pCi/L) in Drinking Water Sampled during 2001 by LA County for Compliance Purposes

Sample Location	Gross Alpha			Gross Beta		
	Calibration Std.	Value	(Uncertainty) ^a	Calibration Std.	Value	(Uncertainty) ^a
Wellheads:						
Pajarito Well Field-PM1	²⁴¹ Am	1.80	(0.40)	¹³⁷ Cs	3.80	(0.60)
	Natural U	2.30	(0.50)	⁹⁰ Sr, ⁹⁰ Y	3.70	(0.60)
Pajarito Well Field-PM3	²⁴¹ Am	0.30	(0.20)	¹³⁷ Cs	2.20	(0.50)
	Natural U	0.40	(0.30)	⁹⁰ Sr, ⁹⁰ Y	2.10	(0.50)
Pajarito Well Field-PM4	²⁴¹ Am	0.80	(0.40)	¹³⁷ Cs	4.30	(0.60)
	Natural U	1.10	(0.50)	⁹⁰ Sr, ⁹⁰ Y	4.10	(0.60)
Guaje Well Field-G2A	²⁴¹ Am	0.50	(0.30)	¹³⁷ Cs	2.10	(0.50)
	Natural U	0.60	(0.30)	⁹⁰ Sr, ⁹⁰ Y	2.00	(0.50)
Guaje Well Field-G3A	²⁴¹ Am	0.10	(0.20)	¹³⁷ Cs	1.80	(0.50)
	Natural U	0.10	(0.30)	⁹⁰ Sr, ⁹⁰ Y	1.80	(0.50)
Guaje Well Field-G4A	²⁴¹ Am	0.60	(0.30)	¹³⁷ Cs	2.00	(0.50)
	Natural U	0.80	(0.30)	⁹⁰ Sr, ⁹⁰ Y	1.90	(0.50)
Otowi Well Field-O1	²⁴¹ Am	1.20	(0.30)	¹³⁷ Cs	4.70	(0.60)
	Natural U	1.50	(0.40)	⁹⁰ Sr, ⁹⁰ Y	4.60	(0.60)
EPA Maximum Contaminant Level		15			NA	
EPA Screening Level		5			50	

^aUncertainties are expressed as one standard deviation.

investigation to characterize any contamination at the facility.

In March 1998, NMED approved a comprehensive hydrogeologic characterization work plan for the Laboratory. The Laboratory developed the Hydrogeologic Workplan (LANL 1998a) to address the DOE Order 5400.1 and Task III of Module VIII of the RCRA Hazardous Waste Facility Permit requirements as described above and in response to NMED's denial of the Laboratory's RCRA operating permit application groundwater monitoring waiver demonstrations. The plan proposes a multiyear drilling and hydrogeologic analysis program to characterize the hydrogeologic setting of the Pajarito Plateau and to assess the potential for groundwater contamination from Laboratory operations. The goal of the project is to develop greater understanding of the geology, groundwater flow, and geochemistry beneath the 43-square-mile Laboratory area and to assess any impacts that Laboratory activities may have had on groundwater quality. The Hydrogeologic Workplan will result in an enhanced understanding of the Laboratory's groundwater setting

and an improved ability to ensure adequate groundwater monitoring. We anticipate completion of the Hydrogeologic Workplan in 2005.

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in the State of New Mexico. Under the regulations, when required by NMED, a facility must submit a groundwater discharge plan and obtain NMED approval (or approval from the Oil Conservation Division for energy/mineral extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan.

The Laboratory has three approved groundwater discharge plans to meet NMWQCC regulations (Table 2-1): one for TA-57 (Fenton Hill); one for the SWS Facility; and one for the land application of dried sanitary sewage sludge from the SWS Facility. The groundwater discharge plan for the land application of sludge has not been renewed by the NMED because the Laboratory has not had land-applied sewage sludge since 1995. The discharge plan has been administra-

2. Compliance Summary

Table 2-10. Radioactivity (pCi/L) in Drinking Water during 2001 by LANL

Sample Location	Gross Alpha			Gross Beta		
	Calibration Std.	Value	(Uncertainty) ^a	Calibration Std.	Value	(Uncertainty) ^a
Wellheads:						
Pajarito Well-PM1	²⁴¹ Am	0.9	(0.3)	¹³⁷ Cs	3.3	(0.5)
	Natural U	1.2	(0.4)	⁹⁰ Sr, ⁹⁰ Y	3.2	(0.4)
Pajarito Well-PM2	²⁴¹ Am	0.0	(0.2)	¹³⁷ Cs	1.6	(0.4)
	Natural U	0.0	(0.3)	⁹⁰ Sr, ⁹⁰ Y	1.6	(0.4)
Pajarito Well-PM3	²⁴¹ Am	0.5	(0.3)	¹³⁷ Cs	3.5	(0.5)
	Natural U	0.6	(0.3)	⁹⁰ Sr, ⁹⁰ Y	3.4	(0.5)
Pajarito Well-PM4	²⁴¹ Am	0.1	(0.2)	¹³⁷ Cs	2.0	(0.4)
	Natural U	0.1	(0.2)	⁹⁰ Sr, ⁹⁰ Y	2.0	(0.4)
Pajarito Well-PM5	²⁴¹ Am	0.0	(0.2)	¹³⁷ Cs	2.3	(0.4)
	Natural U	0.0	(0.3)	⁹⁰ Sr, ⁹⁰ Y	2.2	(0.4)
Guaje Well-G1A	²⁴¹ Am	1.0	(0.3)	¹³⁷ Cs	3.1	(0.5)
	Natural U	1.3	(0.4)	⁹⁰ Sr, ⁹⁰ Y	3.0	(0.5)
Guaje Well-G2A	²⁴¹ Am	0.8	(0.3)	¹³⁷ Cs	2.3	(0.4)
	Natural U	1.0	(0.4)	⁹⁰ Sr, ⁹⁰ Y	2.3	(0.4)
Guaje Well-G3A	²⁴¹ Am	0.9	(0.3)	¹³⁷ Cs	2.7	(0.5)
	Natural U	1.1	(0.4)	⁹⁰ Sr, ⁹⁰ Y	2.7	(0.5)
Guaje Well-G4A	²⁴¹ Am	0.2	(0.3)	¹³⁷ Cs	3.1	(0.5)
	Natural U	0.3	(0.3)	⁹⁰ Sr, ⁹⁰ Y	3.0	(0.5)
Guaje Well-G5A	²⁴¹ Am	0.1	(0.2)	¹³⁷ Cs	1.5	(0.4)
	Natural U	0.1	(0.3)	⁹⁰ Sr, ⁹⁰ Y	1.4	(0.4)
Otowi Well-O4	²⁴¹ Am	0.5	(0.3)	¹³⁷ Cs	3.8	(0.5)
	Natural U	0.7	(0.4)	⁹⁰ Sr, ⁹⁰ Y	3.7	(0.5)
Otowi Well-O1	²⁴¹ Am	1.2	(0.3)	¹³⁷ Cs	3.3	(0.5)
	Natural U	1.6	(0.4)	⁹⁰ Sr, ⁹⁰ Y	3.2	(0.4)
EPA Maximum Contaminant Level		15			NA	
EPA Screening Level		5			50	

^aUncertainties, sigmas, are expressed as \pm one standard deviation (i.e., one standard error).

tively extended. The groundwater discharge plan for the land application of sludge was not renewed in 2001 because the Laboratory is no longer applying sludge; the NMED considers the discharge plan to be administratively extended. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. As of December 31, 2001, NMED approval of the plan was still pending.

b. Compliance Activities. The Groundwater Protection Management Program Plan that ESH-18 administers integrates studies by several Laboratory programs. One of these programs, Hydrogeologic Workplan (LANL 1998a), is an ongoing study of the

hydrogeology and stratigraphy of the region to fulfill requirements in the HSWA Module of the RCRA Hazardous Waste Facility Permit, the groundwater monitoring requirements under the RCRA operating permit, and DOE Order 5400.1. The Laboratory's Groundwater Annual Status Summary Report (Nylander et al., 2002) provides more detailed information on newly collected groundwater data. Drilling progress for the Hydrogeologic Workplan (LANL 1998a) during 2001 included work on the following wells.

- completed three Hydrogeologic Workplan wells (R-22, R-7, R-5) and three investigation wells (MCOBT-8.5, MCOBT -4.4, CdV-R-37-2);

2. Compliance Summary

Table 2-11. Total Trihalomethanes (µg/L) in Drinking Water Sampled during 2001 by LA County for Compliance Purposes

Sample Location	2001 Quarters			
	First	Second	Third	Fourth
Distribution Sites:				
Los Alamos Airport	0.6	4.5	11.2	10.7
White Rock Fire Station	<0.5	<0.5	0.6	0.5
North Community Fire Station	<0.5	2.1	2.0	2.0
S-Site Fire Station	1.4	3.9	10.2	6.5
Barranca Mesa School	<0.5	2.6	5.4	1.7
TA-39, Bldg. 02	5.6	4.2	8.9	7.6
2001 Average of 3.9 µg/L				
EPA Maximum Contaminant Level			80.0	
Sample Detection Limit			0.5	

Table 2-12. Nitrate/Nitrite (as Nitrogen) (mg/L) in Drinking Water Sampled during 2001 by LA County for Compliance Purposes

Sample Location	NO ³ /NO ² (as N)
Wellheads:	
Pajarito Well Field-PM1	0.45
Pajarito Well Field-PM2	0.40
Pajarito Well Field-PM3	0.42
Pajarito Well Field-PM4	0.29
Pajarito Well Field-PM5	0.27
Otowi Well Field-O1	1.17
Otowi Well Field-O4	0.55
Guaje Well Field-G1A	0.45
Guaje Well Field-G2A	0.43
Guaje Well Field-G3A	0.58
Guaje Well Field-G4A	0.60
EPA Maximum Contaminant Levels (MCLs)	10.0

Table 2-13. Inorganic Constituents (mg/L) in Drinking Water during 2001 by LANL

Sample Location	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO ₃ (as N)	Se	Sb	Tl
Wellheads:													
Pajarito Well-PM1	0.002	<0.1	<0.001	<0.001	0.003	0.25	<0.005	<0.0002	<0.01	0.46	<0.005	<0.001	<0.001
Pajarito Well-PM2	0.001	<0.1	<0.001	<0.001	0.004	0.28	<0.005	<0.0002	<0.01	0.31	<0.005	<0.001	<0.001
Pajarito Well-PM3	0.002	<0.1	<0.001	<0.001	0.003	0.30	<0.005	<0.0002	<0.01	0.45	<0.005	<0.001	<0.001
Pajarito Well-PM4	0.001	<0.1	<0.001	<0.001	0.004	0.27	<0.005	<0.0002	<0.01	0.32	<0.005	<0.001	<0.001
Pajarito Well-PM5	<0.001	<0.1	<0.001	<0.001	0.004	0.26	<0.005	<0.0002	<0.01	0.31	<0.005	<0.001	<0.001
Guaje Well-G1A	0.010	<0.1	<0.001	<0.001	0.005	0.51	<0.005	<0.0002	<0.01	0.43	<0.005	<0.001	<0.001
Guaje Well-G2A	0.008	<0.1	<0.001	<0.001	0.004	0.36	<0.005	<0.0002	<0.01	0.41	<0.005	<0.001	<0.001
Guaje Well-G3A	0.003	<0.1	<0.001	<0.001	0.003	0.30	<0.005	<0.0002	<0.01	0.56	<0.005	<0.001	<0.001
Guaje Well-G4A	0.010	<0.1	<0.001	<0.001	0.004	0.41	<0.005	<0.0002	<0.01	0.40	<0.005	<0.001	<0.001
Guaje Well-G5A	0.003	<0.1	<0.001	<0.001	0.002	0.29	<0.005	<0.0002	<0.01	0.48	<0.005	<0.001	<0.001
Otowi Well-O4	0.002	<0.1	<0.001	<0.001	0.003	0.29	<0.005	<0.0002	<0.01	0.39	<0.005	<0.001	<0.001
Otowi Well-O1	0.003	<0.1	<0.001	<0.001	0.004	0.37	<0.005	<0.0002	<0.01	1.10	<0.005	<0.001	<0.001
EPA Maximum Contaminant Levels	0.01a	2.0	0.004	0.005	0.1	4.0	0.2	0.002	0.1	10.0	0.05	0.006	0.002

^a On February 22, 2002, the new arsenic in drinking water rule became effective. Drinking water systems must comply with the new 10 ppb standard by January 23, 2006.

2. Compliance Summary

Table 2-14. Bacteria in Drinking Water Sampled at Distribution System Taps during 2001 by LA County for Compliance Purposes

Month	No. of Samples Collected	No. of Positive Tests		
		Coliform	Fecal Coliform	Noncoliform
January	46	0	0	5
February	47	0	0	2
March	46	0	0	7
April	47	0	0	10
May	45	0	0	0
June	47	0	0	1
July	46	0	0	3
August	47	0	0	4
September	46	0	0	3
October	45	0	0	1
November	45	0	0	4
December	46	0	0	1
Total 2001	553	0	0	41
Maximum Contaminant Level (MCL)		^a	^b	^c

^a The MCL for coliforms is positive samples not to exceed 5% of the monthly total.

^b The MCL for fecal coliforms is no coliform positive repeat samples following a fecal coliform positive sample.

^c There is no MCL for noncoliforms.

started drilling two Hydrogeologic Workplan wells (R-13, R-8). Well Completion Reports for were published for R-9, R-9i, R-12, R-15, and R-19.

- conducted four rounds of characterization sampling at R-15, R-9, R-12, R-9i, and R-19. The notable results of the characterization sampling are as follows:

Tritium measurements from characterization samples collected from alluvial and perched groundwater zones have activities indicative of recharge by water less than 60 years old with tritium readings in the alluvium (80–29,300 pCi/L) and in perched groundwater (Cerro del Rio basalt, 3,770 pCi/L) in Mortandad and Los Alamos Canyons. Because of its short half-life (12.43 years) and volatilization, dilution, and dispersion within the vadose zone, tritium activities are much lower in the regional aquifer at R-15 (<3 pCi/L). Sample results from the regional aquifer at R-7, R-13, R-7, R-19, R-31, CdV-15, and CdV-37 show tritium below the analytical laboratory's minimum level of detec-

tion (<1 pCi/L); this groundwater is much older than 60 years. However, tritium has been measured in the regional aquifer at R-12 (64 pCi/L) and R-25 (11–17 pCi/L) in previous years.

Perchlorate is a mobile anion observed within the alluvium, Cerros del Rio basalt (MCOBT-4.4), and the Puye Formation (R-15) in Mortandad Canyon. Perchlorate was recently detected in intermediate perched groundwater at MCOBT-4.4 at 145 µg/L at sample depths ranging from 494 ft to 532 ft. Concentrations of perchlorate at well R-15 ranged from <2.8 µg/L to 4.19 µg/L during characterization sampling (four quarterly samples) conducted from February 2000 through May 2001. The analytical laboratory method detection limit for perchlorate is 1 µg/L with a reporting limit of 4 µg/L, using ion chromatography. Concentrations of perchlorate measured at well R-15 were very close to both limits, and the analytical laboratory flagged them as estimated detections, or J values. The only detection of perchlorate at well R-15 was at a concentration of 4.19 µg/L measured during the fourth sampling round conducted on May 22,

2. Compliance Summary

- 2001. Perchlorate has not been detected at R-5, R-7, R-9, R-9I, R-12, R-19, R-31, or CdV-15. Otowi-1, a water supply well in Pueblo Canyon, has shown the presence of perchlorate at concentrations less than 6 µg/L.

11. National Environmental Policy Act

a. Introduction. The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4331 et seq.) requires federal agencies to consider the environmental impacts of proposed actions before making decisions. NEPA also requires a decision-making process open to public participation. All activities that the National Nuclear Security Administration (NNSA) or the Laboratory proposes are subject to NEPA review. NNSA is the sponsoring agency for most LANL activities.

NNSA must comply with the regulations for implementing NEPA published by the Council on Environmental Quality (CEQ) at 40 CFR Parts 1500-1508 and the DOE NEPA Implementing Procedures as published at 10 CFR Part 1021. Under these regulations and DOE Order 451.B, NNSA reviews proposed LANL activities and determines whether the activity is categorically excluded from the need to prepare further NEPA documentation based on previous agency experience and analysis or whether to prepare one of the following:

- An Environmental Assessment (EA), which should provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI) for the proposed action, or
- An EIS, which is a detailed written statement of impacts with a subsequent Record of Decision (ROD).

If an EA or an EIS is required, NNSA is responsible for its preparation. In some situations, a LANL project may require an EA or EIS; but, because the project is connected to another larger action that requires an EIS (such as the LANL Site-Wide EIS [SWEIS] or a programmatic EIS done at the nation-wide level), the LANL project may be included in the larger EIS. The LANL project is then analyzed in the larger action or analysis or may later tier off the final programmatic EIS after a ROD is issued. LANL project personnel initiate NEPA reviews by completing environment, safety, and health identification

documents. These documents create the basis for an NNSA NEPA Environmental Review Form, formerly known as a DOE Environmental Checklist. The LANL Ecology Group (ESH-20) prepares these documents using the streamlined format as specified by LAAO.

In January 2000, LANL instituted a new NEPA, cultural, and biological (NCB) review process known as the NCB Laboratory Implementation Requirement (LIR 404-30-02). In 2001, 28 people were trained as NCB line organization reviewers to conduct preliminary screenings that ensure compliance with applicable NCB requirements. In 2001, ESH-20 held two training courses and two refresher/update classes for LANL NCB reviewers. ESH-20 also published the Facility NCB Reviewer Determination Documents (LA-UR-01-1273) in March 2001. This compendium provides NCB reviewers with succinct and easily referenced guidance about the operational envelopes and capabilities for each of the 15 key facilities analyzed in the SWEIS.

b. Compliance Activities. In 2001, LANL sent 45 NEPA Environmental Review Forms to NNSA compared with 61 in 2000. NNSA categorically excluded 22 new actions and amended the categorical exclusion for another 21 approved actions. LANL applied NNSA “umbrella” categorical exclusion determinations for 122 actions in 2001, compared with 209 in 2000. NNSA made seven EA determinations and issued two FONSIIs in 2001. Implementing the NCB review process and the use of the SWEIS internally at ESH-20 likely accounts for the observed reductions in NEPA reviews.

c. Environmental Impact Statements, Supplement Analyses, and Special Environmental Analyses. The Laboratory did not complete any supplement or special environmental analyses in 2001. One draft EIS completed in 2001 considers a LANL capability:

Draft Environmental Impact Statement for the Proposed Relocation of TA-18 Capabilities and Materials at the Los Alamos National Laboratory (DOE/EIS-0319). This draft EIS was released for public review and comment in August 2001. It evaluates the potential direct, indirect, and cumulative environmental impacts associated with relocating LANL’s TA-18. The alternatives include

- using a different site at LANL (the Preferred Alternative) and
- relocating to Sandia National Laboratories/New Mexico at Albuquerque, the Nevada Test Site

near Las Vegas, Nevada, or the Argonne National Laboratory-West near Idaho Falls, Idaho.

The EIS also analyzes upgrading the TA-18 facilities at LANL. As required by regulations, the *TA-18 Relocation EIS* also evaluates the No Action Alternative of maintaining the operations at the current TA-18 location.

d. Environmental Assessments Completed during 2001. Three EA-level NEPA documents were prepared at the Laboratory in 2001. A brief description of each EA follows.

Environmental Assessment for Coiled-Tubing Drilling Experiment at San Ysidro, New Mexico, BLM Rio Puerco Resource Management Area, Los Alamos National Laboratory document LA-UR-01-2926 (2001). LANL ESH-20 staff assisted the Bureau of Land Management (BLM) in writing this assessment of a test method proposed to improve microdrilling technology, develop and test miniaturized down-hole instrumentation, and demonstrate “proof-of-principle” of the new technology in an appropriate geologic setting. University of California employees, LANL, or their contractors performed the on-site work once the BLM issued a FONSI on June 25, 2001.

Environmental Assessment for Construction and Operation of a New Office Building and Related Structures within TA-3 at Los Alamos National Laboratory, Los Alamos, New Mexico, NNSA-EA-1375 (July 2001). This assessment considered how to replace the LANL Administration Building (Building 3-43) at TA-3. This building has many identified structural, systemic, and security problems that NNSA needs to correct so that programmatic, management, and support functions housed within can continue to function at LANL with a high level of efficiency. The Proposed Action is to construct and operate a multistoried office building to house about 700 personnel, a lecture hall, and a separate multilevel parking structure. NNSA would demolish Building 3-43 as well. A plan would be developed to document and preserve the building’s historic attributes. Cumulative effects of the Proposed Action, along with past, present, and reasonably foreseeable actions, on LANL and surrounding lands are anticipated to be negligible. The NNSA signed a FONSI for this EA on July 26, 2001.

Environmental Assessment for the Proposed Construction and Operation of a New Interagency Emergency Operations Center at Los Alamos National Laboratory, Los Alamos, New Mexico, DOE/EA-1376 (2001). This assessment considered how to

replace the existing emergency operations center located in TA-59 to remedy the insufficiencies and inadequacies NNSA identified after the Cerro Grande fire. The Proposed Action is the construction and operation of a new Interagency Emergency Operations Center on a five-acre site at TA-69. The 30,000-sq-ft facility would also have a garage, a 130-car parking lot, and a 150-ft-tall fire-suppression water storage tank with antenna attachments. The new center and associated structures are anticipated to have minimal traffic, visual, and environmental effects. The site is currently vacant but disturbed because of prior tree-thinning operations in this area and fire access roads. Cumulative effects of the Proposed Action, along with past, present, and reasonably foreseeable actions on LANL and surrounding lands, are anticipated to be negligible. The NNSA signed a FONSI for this EA on July 26, 2001.

e. Environmental Assessments in Progress during 2001. Five environmental assessments were in various stages of development during 2001:

- Environmental Assessment for the Proposed TA-16 Engineering Complex Refurbishment and Consolidation at Los Alamos National Laboratory, Los Alamos, New Mexico.
- Environmental Assessment for the Proposed Construction and Operation of a Biosafety Level 3 Facility at Los Alamos National Laboratory, Los Alamos, New Mexico.
- Environmental Assessment for the Proposed Easement for the Construction and Operation of a 12-in. Natural Gas Pipeline by PNM in Los Alamos Canyon, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Proposed Future Disposition of Certain Cerro Grande Fire Flood and Sediment Retention Structures at Los Alamos National Laboratory.
- Environmental Assessment of the Proposed Disposition of the Omega West Facility at Los Alamos National Laboratory, Los Alamos, New Mexico.

f. Mitigation Action Plans. As part of the implementation requirements under NEPA, NNSA prepares and is responsible for implementing Mitigation Action Plans (MAPs) (10 CFR 1021, Section 331 [a] July 9, 1996). MAPs may apply to individual or site-wide projects and are generally project specific and are designed to (1) document potentially adverse

2. Compliance Summary

environmental impacts of a proposed action, (2) identify impact mitigation commitments made in the final NEPA documents (FONSI or RODs), and (3) establish action plans to carry out each commitment. The MAP Annual Report (MAPAR) reports the implementation status of each MAP to the public. ESH-20 coordinates the implementation of the following NNSA MAPs at the Laboratory.

Site-Wide Environmental Impact Statement. DOE issued this MAP in September 1999. The MAP provides details about the mitigation actions found in the ROD and tasks LANL with preparation of a project plan to implement them. Mitigations include specific measures to further minimize the impacts identified in the SWEIS as a result of operations (e.g., electrical power and water supply, waste management, and wildfire) and measures to enhance existing programs to improve operational efficiency and minimize future potential impacts from LANL operations (e.g., cultural resources, traditional cultural properties, and natural resources management). The Laboratory expects to complete specific measures by FY 2006, and the enhancement of existing programs should be implemented by FY 2003. A MAPAR is prepared annually.

Dual-Axis Radiographic Hydrodynamic Test Facility Mitigation Action Plan. DOE issued this MAP in 1995. On January 14, 1999, the DARHT MAPAR for 1998 was released to the public for review and comment. During 2000, the Laboratory implemented all operations-related mitigation measures. The construction-related mitigation measures were completed in 1999. The scope of operations-related mitigation measures included ongoing environmental chemistry baseline monitoring, ongoing monitoring of the Nake'muu cultural resources site, and human health and safety mitigations for operations. The DARHT MAPAR for 2000 was distributed to NNSA public reading rooms on January 29, 2001.

Low-Energy Demonstration Accelerator (LEDA) Mitigation Action Plan. DOE issued this MAP in 1996. On January 29, 2001, the LEDA MAPAR for 2000 was distributed to NNSA public reading rooms. All MAP commitments for preventing soil erosion and monitoring industrial NPDES outfalls and potential wetlands formation in and around the LEDA facility are being implemented and are on schedule.

Special Environmental Analysis (SEA) of Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory, Los Alamos,

New Mexico. The NNSA prepared and issued the SEA in September 2000. The SEA was prepared pursuant to the Council on Environmental Quality regulations implementing NEPA under emergency circumstances and NNSA NEPA regulatory requirements by providing an analysis of the Cerro Grande fire emergency fire suppression, soil erosion, and flood control actions that NNSA and LANL took from May through November 2000. As part of the SEA, NNSA identified various mitigation measures that must be implemented as an extension of the fire suppression, erosion, and flood control actions. NNSA assigned the implementation of specific mitigation measures to the LANL management and operations contractor, UC, on December 18, 2000 (DOE 2000). Monitoring results of the mitigation effectiveness and the environmental effects of the emergency actions recognized later are to be made available to the public through an annual mitigation tracking report. The first annual report covering the fiscal year beginning October 1, 2000, and ending on September 30, 2001 will be issued in early 2002.

Other Studies Completed in 2001. LANL ESH-20 prepared four other NEPA-related studies in 2001. Three of these support the proposed Advanced Hydrotest Facility project, and the other was prepared to support an NNSA-wide siting study for the Advanced Accelerator Applications project.

“Accelerator-Driven Test Facility Site Selection,” Los Alamos National Laboratory document LA-UR-01-3372 (2001).

“Preliminary Hydro-Geologic Assessment of the Proposed AHF Site in TA-53,” Los Alamos National Laboratory document LA-UR-01-3479 (2001).

“Technical Source Document for the Proposed Advanced Hydrotest Facility in Technical Areas 5, 53, and 72: Geology, Soils, Hydrology, and Preexisting Potential Contaminant Release Sites with a Preliminary Assessment of Potential Environmental Impacts,” Los Alamos National Laboratory document LA-UR-01-4280 (2001).

“Cultural Resources Status of the Proposed Advanced Hydrotest Facility Site Location in TAs-53, -72, -73, and -5 (LANSCE Site) at Los Alamos National Laboratory, Los Alamos, New Mexico,” Los Alamos National Laboratory document LA-UR-01-5721 (2001).

12. Integrated Resources Management

The development and implementation of the Integrated Resources Management Plan (IRMP) is mandated under the ROD and MAP for the LANL SWEIS. DOE/NNSA and LANL completed the Preliminary Draft Integrated Resources Management Plan (IRMP) in May 2001. The Preliminary Draft was distributed to stakeholders and other interested parties for review and comment in June 2001. The final IRMP will be completed, and Laboratory-wide implementation initiated, in late 2002. The IRMP involves DOE/NNSA and multiple LANL organizations and is being developed as a mission-oriented tool for integrating facility and land use planning activities with the management of natural and cultural resources. As part of the IRMP, LANL continued to develop several resource-specific management plans during 2002.

13. Cultural Resources

a. Introduction. The ESH-20 Cultural Resources Team is responsible for developing the Cultural Resources Management Plan (CRMP), building and maintaining a database of all cultural resources found on DOE land, supporting DOE's compliance with the requirements applicable to cultural resource legislation as listed below, and providing appropriate information to the public on cultural resource management issues. Cultural resources are defined as archaeological materials and sites dating to the prehistoric, historic, or European contact period that are currently located on or beneath the ground; standing structures that are over 50 years old or are important because they represent a major historical theme or era; cultural and natural places, select natural resources, sacred objects and sites that have importance to American Indians; and American folklife traditions and arts.

b. Compliance Overview. Section 106 of the National Historic Preservation Act, Public Law 89-665, implemented by 36 CFR 800, requires federal agencies to evaluate the impact of proposed actions on cultural resources. Federal agencies must also consult with the State Historic Preservation Officer (SHPO) and/or the Advisory Council on Historic Preservation about possible adverse effects on National Register of Historic Places eligible resources.

During 2001, ESH-20 Laboratory Cultural Resources Team evaluated 1026 Laboratory proposed actions and conducted 20 new field surveys to identify

cultural resources. DOE sent eight survey results to the SHPO for concurrence in findings of effects and determinations of eligibility for National Register inclusion of cultural resources located during the survey. The Governors of San Ildefonso, Santa Clara, Cochiti, and Jemez Pueblos and the President of the Mescalero Apache Tribe received for comment copies of two reports to identify any traditional cultural properties that a proposed action could affect. ESH-20 identified adverse effects to two historic buildings that were decommissioned and decontaminated in 2001. Personnel documented and interpreted the historic buildings to resolve the adverse effects.

The American Indian Religious Freedom Act of 1978 (Public Law 95-341) stipulates that it is federal policy to protect and preserve the right of American Indians to practice their traditional religions. Tribal groups must receive notification of possible alteration of traditional and sacred places. The Native American Grave Protection and Repatriation Act of 1990 (Public Law 101-601) states that if federal activities inadvertently disturb burials or cultural objects, work must stop in that location for 30 days, and the closest lineal descendant must be consulted for disposition of the remains. No discoveries of burials or cultural objects occurred in 2001. The Archaeological Resources Protection Act (ARPA) of 1979 (Public Law 96-95) provides protection of cultural resources and sets penalties for their damage or removal from federal land without a permit. No ARPA violations were recorded on DOE land in 2001.

c. Compliance Activities.

Nake'muu. Nake'muu is one of only a few standing-walled ancestral pueblos remaining in the Jemez Mountains. It dates from circa 1200–1325 A.D. and contains 55 rooms with walls standing up to 6 ft high. It is one of the best-preserved ruins on the Pajarito Plateau. The site is ancestral to the people from San Ildefonso Pueblo who refer to it in their oral histories and songs. They are invited for annual visits to Nake'muu to personally view the ruins and consult on the long-term status of the site and possible stabilization options.

In maintaining institutional compliance with NEPA, the ESH-20 Cultural Resources Team, as part of the DARHT MAP, is monitoring the effects of DARHT operations on the standing-walled masonry at Nake'muu. In a 1997 baseline assessment, the Mesa Verde Architectural Team suggested that the ambient

2. Compliance Summary

environment posed the greatest threat to the pueblo. This suggestion is primarily based on condition assessment and the observation that rainfall and snowmelt have eroded adobe mortar, rendering many of the walls unstable. The four-year monitoring program (1998–2001) indicates that on the average about 1.3% of the chinking stones and 0.6% of the masonry blocks are falling out of the walls on an annual basis. Two test shots were fired at the DARHT facility to evaluate electronic monitoring equipment at Nake'muu. Accelerometers were placed on two walls at Nake'muu to record the events. After integrating the records, we found a peak displacement of 0.04 mm. Therefore, the walls only moved a maximum distance of 40 μm during the test. Future studies will evaluate whether the daily heating and cooling of the standing walls can produce a similar amount of wall movement. In summary, the preliminary results of this four-year study indicate some minor changes in the standing-walled masonry at Nake'muu; however, a long-term database must be established to provide the basis for a more meaningful interpretation of monitoring program results. See Vierra et al. (2002) for more information on this project.

Traditional Cultural Properties Consultation Comprehensive Plan. In 2001, the Cultural Resources Team assisted DOE/LAAO in implementing the Traditional Cultural Properties Consultation Comprehensive Plan. This plan provides the framework to open government-to-government consultations between DOE/LAAO and interested Native American tribal organizations on identifying, protecting, and gaining access to traditional cultural properties and maintaining confidentiality of sensitive information. Representatives from Cochiti, Jemez, Santa Clara and San Ildefonso Pueblos attended initial consultation meetings. Twenty-one additional tribes in the Southwestern United States received invitations to participate in the Traditional Cultural Properties consultation process.

Land Conveyance and Transfer. Public Law 105-119, November 1997, directs DOE to convey and transfer parcels of DOE land in the vicinity of the Laboratory to the County of Los Alamos, New Mexico, and to the Secretary of the Interior, in trust for the San Ildefonso Pueblo. In support of this effort, the Cultural Resources Team conducted historic property inventories and evaluations, as required under Section 106 of the National Historic Preservation Act, in preparation for the eventual transfer of lands out of federal ownership. This effort has included the ar-

chaeological survey of 4,700 acres of Laboratory lands and the inventory and evaluation of 47 buildings and structures located on the transfer parcels. In 2001, the Cultural Resources Team developed a draft Programmatic Agreement in consultation with the Advisory Council on Historic Preservation and the New Mexico State Historic Preservation Officer. The draft Programmatic Agreement will be distributed in the spring of 2002 to Los Alamos County, the Pueblo of San Ildefonso, and the interested public for comment. Implementation of the Programmatic Agreement will begin in the summer of 2002.

Cerro Grande Fire Recovery. The Cultural Resources Team is conducting fire damage assessments of approximately 7,500 acres of LANL property burned during the May 2000 Cerro Grande fire. It is estimated that team personnel will visit 519 historic properties during the ongoing assessment activities. The assessments include photography, evaluation of fire impacts, global positioning system (GPS) recording of site locations, site rehabilitation, and long-term monitoring. Preliminary results of the first phase of assessments indicate that the fire damaged the Homestead Period wooden structures most severely, completely destroying a number of homestead cabins. Reassessments of National Register of Historic Places eligibility will be required at these sites.

14. Biological Resources including Floodplain and Wetland Protection

a. Introduction. The DOE and the Laboratory comply with the Endangered Species Act; the Migratory Bird Treaty Act; the Bald Eagle Protection Act; Presidential Executive Order 11988, Floodplain Management; Presidential Executive Order 11990, Protection of Wetlands; and Section 404 of the Clean Water Act. The Laboratory also protects plant and animal species listed by the New Mexico Conservation Act and the New Mexico Endangered Species Act.

b. Compliance Activities. During 2001, the ESH-20 Biology Team reviewed 378 proposed Laboratory activities and projects for potential impact on biological resources, including federally listed threatened and endangered (T&E) species. These reviews evaluate the amount of previous development or disturbance at the site, determine the presence of wetlands or floodplains in the project area, and determine whether habitat evaluations or species-

specific surveys are needed. Of the 378 reviews, the Biology Team identified 75 projects that required habitat evaluation surveys to assess whether the appropriate habitat types and parameters were present to support any threatened or endangered species; of those, 35 were identified as having floodplains or wetlands issues. As part of the standard surveys associated with the Threatened and Endangered Species Habitat Management Plan (HMP), the Biology Team conducted approximately 30 species-specific surveys to determine the presence or absence of a threatened or endangered species at LANL. The Laboratory adhered to protocols set by the US Fish and Wildlife Service and to permit requirements of the New Mexico State Game and Fish Department.

c. Biological Resource Compliance Documents. In 2001, the Biology Team prepared 20 biological resource documents, such as biological assessments, biological evaluations, floodplains and wetlands assessments, and other compliance documents. These documents included, among others, a biological assessment of the conveyance and transfer of land tracts (Haarmann and Loftin 2001) and a floodplains and wetlands assessment for the potential effects of the Wildfire Hazard Reduction Plan (Marsh 2001). DOE determined that these projects may affect, but are not likely to adversely affect, individuals of threatened and endangered species or their critical habitat; the US Fish and Wildlife Service concurred with these determinations. The Biology Team contributed to the continued implementation of the Threatened And Endangered Species Habitat Management Plan (LANL 1998b). Site plans were successfully used to further evaluate and manage the threatened and endangered species occupying DOE/Laboratory property.

d. Effects of the Cerro Grande Fire. During 2001, the continuing effects of the Cerro Grande fire of 2000 had the greatest impact to ecological resources. During 2001, we began modifying the HMP to reflect post-fire habitat changes. The Laboratory completed several contaminant studies and continued risk assessment studies on the food chain for threatened and endangered species habituating Laboratory lands, including potential impacts from the fire. Studies continued also on soils, vegetation, and erosion. Fire mitigation measures were undertaken as well in projects such as the Wildfire Hazard Reduction Project that ESH-20 oversaw.

C. Current Issues and Actions

1. Compliance Agreements

a. New Mexico Hazardous Waste Management Regulations Compliance Orders. On June 25, 1998, the Laboratory received CO-98-02 that alleged two violations of the NM Hazardous Waste Management Regulations for the storage of gas cylinders at TA-21. NMED proposed civil penalties of over \$950,000. The Laboratory filed its answer to the CO on August 10, 1998, meeting the compliance schedule by demonstrating that all gas cylinders had been disposed of properly. Efforts to resolve this CO continued during 2001.

On December 21, 1999, the Laboratory received CO-99-03. It covered the alleged deficiencies the NMED Hazardous and Radioactive Materials Bureau discovered during a five-month inspection that took place in 1997. The inspection was called “wall-to-wall” because NMED personnel walked every space at the Laboratory—storage areas, laboratories, hallways, stairwells, and the areas around buildings—looking for improperly stored hazardous chemicals. In past inspections, only designated storage areas were included. Twenty-nine deficiencies were alleged with over \$1 million in proposed penalties. The Laboratory prepared and submitted its response to the CO and requested a hearing during 2000. Negotiations continued during 2001.

The Laboratory received CO-99-01 on December 28, 1999, in response to the NMED inspection conducted between August 10 and September 18, 1998. The inspection team visited approximately 544 sites at the Laboratory. Thirty violations were alleged in the CO. Total penalties proposed were almost \$850,000. The Laboratory prepared and submitted its response to the CO and requested a hearing during 2000. Negotiations to resolve this CO are expected to begin in 2002.

b. Notice of Violation. The NMED issued an NOV to UC and DOE on October 9, 2001, as a result of the 2001 RCRA hazardous waste compliance inspection (April 23 to the end of August 2001). The NOV identified 18 categories of violations, each with one or more instances of alleged noncompliance. The types of issues described ranged from waste determinations, generator’s control of waste, exceeding waste storage time, incompatible chemical storage, training, emergency response, waste manifesting, mixed waste

2. Compliance Summary

management under the site treatment plan, waste piles, and prevention of releases. UC/DOE's response to the NOV is due to NMED on February 4, 2002.

D. Consent Decree

1. Clean Air Act Consent Decree/Settlement Agreement

During 1997, DOE and the Laboratory Director entered into a Consent Decree and a Settlement Agreement to resolve a lawsuit that the Concerned Citizens for Nuclear Safety filed. The lawsuit, filed in 1994, alleged that the Laboratory was not in full compliance with the CAA Radionuclide NESHAP, 40 CFR 61, Subpart H. The decree and agreement require actions that will continue through 2002 and, depending upon the results of the independent audits, may continue through 2004. All of the provisions of the decree and agreement were met during 2001 and are described in detail at <http://www.air-quality.lanl.gov/ConsentDecree.htm> on the World Wide Web.

E. Significant Accomplishments

1. Follow-Up to the Cerro Grande Fire

Following the Cerro Grande fire, the Laboratory's Emergency Rehabilitation Team (ERT) completed initial assessments and land rehabilitation treatments. The rehabilitation effort on LANL property lasted for approximately 10 weeks. Crews treated approximately 1600 acres using methods much like those used by the Cerro Grande fire Burned Area Emergency Rehabilitation (BAER) team.

To determine the success of the treatments applied, LANL has developed the Burned Area Rehabilitation Treatment (BART) system. BART is a Geographic Information System (GIS)-based tracking and monitoring system designed to identify and generate reports of additional work needed in the treatment units based on field assessments. Field crews collect information on the fire recovery process by documenting recovery on BART field forms and photo points. Comparison of pictures of the same site, over time, will provide visual evidence of vegetation changes and site recovery.

Two rounds of field assessments, implementing the BART field forms, were conducted in 2001. The first inspections began in May 2001 and were completed

by June 10, 2001. The crews filled out field forms and established photo points at each treatment areas. The information collected was entered into the BART database. The second assessment occurred in December, although conditions were not ideal for observations because of snow in some units.

In general, the rehabilitation units are in good to excellent condition. In most of the units, the seeded vegetation is established and providing ground cover. Very few wattles were damaged. Most damage was due to poor installation, animals tearing apart the wattles to get to the straw, and blowouts in some of the channel placements. A high percentage of the wattles contained sediment; however, because the ground cover and vegetative growth were excellent, the sediment-filled wattles did not cause great concern. The crews observed very little evidence of down-cutting below wattles or rill erosion on the slopes. Most of the mulch has been incorporated with the vegetation; however, in some areas the mulch has been blown away by high winds. In general, the rehabilitation treatments have stabilized the exposed soil in the rehabilitation units.

Restoration activities conducted last year were successful in establishing ground cover on areas burned by the Cerro Grande fire. Table 2-15 details the results of the BART survey in 2001. Vegetative cover conditions improved from June to December. The 2001 monsoon season was relatively short-lived and did not produce significant storms over the burn units on the LANL site. Effective ground cover decreased from June to December (although snow and late season conditions may have influenced the surveyor's estimations). We will continue to use the BART system to track the recovery of and monitor the rehabilitation units over the next few years. We will maintain existing treatments and apply additional treatments, as needed.

F. Significant Events

1. Effect of the Events of September 11

Because of heightened security awareness after the terrorist attack on the United States, DOE and the Laboratory examined the material available on the Laboratory's World Wide Web sites and moved some information behind the Laboratory's firewall. At this time, the EIS, the ESR, and certain other documents may not be available online to the general public.

Table 2.15. BART Survey Results for 2001

BART Survey	Vegetative Cover (%) ^a	Effective Ground Cover (%) ^b
June 2001 ^c	36.7	62.1
December 2001 ^d	45.2	56.7

^aVegetative cover is new and existing plant growth.

^bEffective groundcover includes vegetative cover plus nonliving litter, mulch, needlecast, and deadfall.

^c39 units inspected.

^d37 units inspected.

G. Awards

1. Achievement Awards

a. DOE. Members of the ESH-18 NPDES team won a 2001 DOE Albuquerque Operations Performance Excellence Award for the Laboratory's NPDES permit application.

b. Los Alamos Achievement. A member of ESH-19 received a Los Alamos Achievement Award for her outstanding accomplishments facilitating the treatment and disposal of 300 containers of potentially explosive reactive materials, which enabled the Laboratory to meet its commitment to DOE to evaluate both the policy on the shelf-life of such chemicals and the hazard level of the chemical inventory.

2. Pollution Prevention Awards

a. DOE Pollution Prevention Awards. The Laboratory won two out of five nominations submitted for the Department of Energy Pollution Prevention (P2) Awards. The DOE P2 Awards Program rewards pollution prevention, recycling, and affirmative procurement activities completed or performed in fiscal year 2001. These awards are typically given out by the Secretary of Energy at a ceremony in Washington. The winners are as follows:

- Creating Jobs and Awareness through a Native American Recycling Center (http://emeso.lanl.gov/eso_projects/p2_awards/DOE_P2/DOE_p2/NambeAward3Fweb1.pdf)

This innovative project addresses two problems facing northern New Mexico: high unemployment and poverty and increasing strains on waste

management infrastructure. Nambé Pueblo, in partnership with the Laboratory and JCNM, has stepped forward to help reduce waste and pollution, build community awareness, and create viable economic opportunities in the region. These partners have launched a recycling facility that provides jobs, services recycling needs of surrounding communities, redirects landfill waste and construction debris to alternative uses, and promotes education and outreach.

- Closing the Circle on One Problematic Nitrate Waste Stream at Los Alamos National Laboratory's Nuclear Materials Technology Division (http://emeso.lanl.gov/eso_projects/p2_awards/DOE_P2/DOE_p2.nmt2_nomination1Web.pdf).

The Actinide Process Chemistry Group has closed the circle on one of the most problematic waste streams in the DOE complex: plutonium-contaminated nitric acid. The Nitric Acid Recovery System (NARS) at the Plutonium Processing and Handling Facility at TA-55 is a distillation process that recycles acid used for plutonium dissolution and recovery. NARS virtually eliminates this waste stream. NARS allows LANL to avoid discharges of TA-55-generated nitrates to the environment. NARS also recycles 100% of radioactivity back into the system, generating activity-free product water. The return on investment was 128% on a \$2,000,000 capital cost.

Members of the NPDES team and Facility and Waste Operations (FWO) Waste Facility Management Unit teamed up for a 2001 DOE Pollution Prevention National Runner Up Award and a Certificate of Achievement, "Greening the Government" Award,

2. Compliance Summary

White House Task Force on Recycling, for improvements in wastewater quality and pollution prevention at the TA-50 RLWTF.

b. Green Zia Awards. In 2001, seven Laboratory organizations and projects received recognition from the New Mexico Green Zia Environmental Excellence program for their noteworthy environmental performance in pollution prevention. The Environmental Science and Waste Technology (E), Human Resources, and Engineering Science and Applications divisions won Achievement Awards. Los Alamos' Business Operations and FWO divisions, Nuclear Materials Technology's PIT Disassembly and Surveillance Tech Group, and Aramark, the Laboratory's food service provider, won Commitment Awards. It is the second year in a row that E Division earned achievement-level recognition. Governor Gary Johnson and State Environment Department Secretary Peter Maggiore recognized the seven Laboratory organizations at a ceremony in La Cienega.

Recognition at the Commitment Level indicates that independent program examiners and judges believe the organization's management has made a strong commitment to pollution prevention and the organization is establishing a basic, systematic pollution prevention program. Recognition at the Achievement Level shows that examiners and judges believe the organization has developed its pollution prevention program into a prevention-based environmental management system and can demonstrate measurable results. The Environmental Stewardship Office (E-ESO) coordinates Green Zia activities at the Laboratory. The NMED sponsors the Green Zia program, and the New Mexico Environmental Alliance, a partnership of state, local, and federal agencies, academia, private industry, and environmental advocacy groups, administers it.

Descriptions of the award-winning efforts are available at http://emeso.lanl.gov/eso_projects/green_zia/Successes/successes.html on the World Wide Web.

c. Laboratory Pollution Prevention Awards.

E-ESO presents these awards to organizations at the Laboratory to recognize the pollution prevention successes of individuals or teams that have minimized waste, conserved water or electricity, reduced air or water pollution, or procured products with recycled content. Award summaries are available at http://emeso.lanl.gov/eso_projects/p2_awards/01P2.html on the World Wide Web. Summaries of projects specific to environmental compliance and monitoring are presented below.

An ESH-19 employee received a Pollution Prevention Award for devising an analytical tool to accurately determine whether tritium is present in a waste sample to avoid mischaracterization of the waste.

Members of the ER Project took a proactive approach to categorizing clean waste and were able to prevent 2,400 y³ of waste from going to a TSCA facility.

Members of ESH-18, working with a team from the TA-50 RLWTF, fine tuned a new treatment process that reduced the amount of both radioactive material and nitrates discharged by 94% from CY 1999. As a result, the facility had no violations of the New Mexico discharge standards, no violations of NPDES permit limits, and no exceedances of the DOE water quality standards. In addition, FWO personnel won an award for implementing water conservation measures for dissolution of the clarifier chemicals, lime, and ferric sulfate, saving 650,000 gal. of potable water each year.

Members of ESH-18, ESH-19 and JCNNM investigated the source of PBCs found in sewage sludge at the TA-46 SWS and discovered remnants of old PCB spills in sewer lines. The lines were cleaned, allowing safe disposal of 23.5 dry tons of sanitary treatment solids as non-TSCA regulated waste.

H. References

- Corps 1989: US Army Corps of Engineers, "Federal Manual for Identifying and Delineating Jurisdiction Wetlands," EO11990, US Government Printing Office, Washington, DC (1989).
- DOE 1999: US Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory, Vols I-IV," DOE/EIS-0238 (January 1999).
- ER 2001: Environmental Restoration Project, "Quarterly Technical Report October-December 2000," Los Alamos National Laboratory document LA-UR-01-0547 (February 2001).
- Erpenbeck and White 2002: G. Erpenbeck and J. L. White, "2001 Los Alamos National Laboratory Hazardous Waste Inventory," Los Alamos National Laboratory document LA-UR-02-889 (February 2002).
- ESP 1996: Environmental Surveillance Program, "Environmental Surveillance and Compliance at Los Alamos during 1995," Los Alamos National Laboratory report LA-13210-ENV (October 1996).
- ESP 1997: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1996," Los Alamos National Laboratory report LA-13343-ENV (September 1997).
- ESP 1998: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1997," Los Alamos National Laboratory report LA-13487-ENV (September 1998).
- ESP 1999: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1998," Los Alamos National Laboratory report LA-13633-ENV (September 1999).
- ESP 2000: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1999," Los Alamos National Laboratory report LA-13775-ENV (December 2000).
- Haarmann and Loftin 2001: T. K. Haarmann and S. R. Loftin, "Biological Assessment for the Conveyance and Transfer of Land Tracts at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-01-4663 (2001).
- LANL 1998a: Water Quality & Hydrology Group, "Hydrogeologic Workplan," Final Version, Los Alamos National Laboratory (May 1998).
- LANL 1998b: "Threatened and Endangered Species Habitat Management Plan Overview," Los Alamos National Laboratory document LALP-98-112 (1998).
- Marsh 2001: L. K. Marsh, "A Floodplains and Wetlands Assessment for the Potential Effects of the Wildfire Hazard Reduction Project," Los Alamos National Laboratory document LA-UR-01-3643 (July 2001).
- NMEIB 1995: New Mexico Environmental Improvement Board, State of New Mexico, "New Mexico Drinking Water Regulations" (as amended through January 1995).
- Nylander et al., 2002: C. L. Nylander, K. A. Bitner, K. Henning, A. S. Johnson, E. H. Keating, P. Longmire, B. D. Newman, B. Robinson, D. B. Rogers, W. J. Stone, and D. Vaniman, "Draft Groundwater Annual Status Report for Fiscal Year 2001," Los Alamos National Laboratory report LA-13820-SR (2002).
- Shaull et al., 2002: D. A. Shaull. "Surface Water Data at Los Alamos National Laboratory: 2001 Water Year,"
- Vierra et al., 2000: B. J. Vierra, L. V. Nordby, and G. S. Martinez, "Nake'muu: Village on the Edge," Los Alamos National Laboratory document LA-UR-00-5163 (2000).

3. Environmental Radiological Dose Assessment





3. Environmental Radiological Dose Assessment

contributing authors:

Michael McNaughton, Keith Jacobson, and Lars Soholt

Abstract

We calculated potential radiological doses to members of the public who may be exposed to Los Alamos National Laboratory (LANL or the Laboratory) operations. The population within 80 km of LANL received a collective dose of 1.6 person-rem, which is consistent with previous years. The calculated maximum off-site radiation dose to a member of the public from Laboratory sources was at East Gate and was 1.9 mrem. The calculated maximum on-site individual exposure to a member of the public is 4.2 mrem, which compares with 13 mrem in 2000. No health effects would be expected from these doses. We also concluded that there was no significant dose related to LANL activities from ingesting locally gathered food and water in Los Alamos or White Rock. Similarly, dose assessments of the aftermath of the Cerro Grande fire demonstrated that no significant doses could be attributed to the fire. Doses to nonhuman biota in the LANL area are well below the Department of Energy's interim standards for the protection of biota.

To Read About . . .

Turn to Page . . .

<i>Overview of Radiological Dose Equivalents</i>	65
<i>Dose Calculations</i>	68
<i>Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation</i>	74
<i>Effect to an Individual from Laboratory Operations</i>	75
<i>Glossary of Terms</i>	547
<i>Acronyms List</i>	557

A. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented here are calculated doses received by individuals exposed to radiation or radioactive material. The “effective dose equivalent” (EDE), referred to here as “dose,” has been calculated using “radiation weighting factors” and “tissue weighting factors” to adjust for the effects of the various types of radiation on the various tissues in the body. The final result, measured in mrem, is a measure of the overall risk to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium.

Federal government standards limit the dose that the public may receive from Los Alamos National Laboratory (LANL or the Laboratory) operations. The Department of Energy (DOE 1993) public dose limit to any individual is 100 mrem per year received from all pathways (i.e., all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct radiation). The dose standard of the Environmental Protection Agency (EPA), which is codified in the Code of Regulations (40 CFR 61: EPA 1986),

further restricts the dose received from airborne emissions of radionuclides to 10 mrem per year. These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from public water supplies are also limited according to the Safe Drinking Water Act, either by established maximum contaminant levels for some radionuclides or by dose (4 mrem/year for man-made radionuclides, beta/photon emitters) (EPA 2000); see Appendix A.

B. Public Dose Calculations

1. Scope

The objective of our dose calculations is to report incremental (above-background) doses caused by LANL operations. Therefore, we do not include dose contributions from radionuclides present in our natural environment or from radioactive fallout unless we identify LANL as the source for these radionuclides. Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

3. Environmental Radiological Dose Assessment

- (1) *the entire population within 80 km of the Laboratory;*
- (2) *the maximally exposed individual (MEI) who is not on LANL/DOE property (referred to as the off-site MEI);*
- (3) *the on-site MEI, defined as a member of the public who is on LANL/DOE property, such as Pajarito Road;*
- (4) *residences in Los Alamos and White Rock; and*
- (5) *residences adjacent to Acid Canyon.*

2. General Considerations

We use the standard methods recommended by federal agencies to determine radiation doses (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997; and NRC 1977). We begin with measurements and extend these with calculations using standard models and methods that are used worldwide.

a. Direct Radiation Exposure. Direct radiation from gammas or neutrons is measured at more than 100 locations near LANL (Chapter 4, Sections C and H). Doses above natural background are observed near Technical Area (TA) -3, TA-18, TA-53, and TA-54.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source, e.g., on Pajarito Road. At distances more than 1 km, the inverse-square law combined with scattering and attenuation in the air reduces the dose to much less than 0.1 mrem per year, which cannot be distinguished from natural background radiation. In practice, the only significant doses from direct radiation are on Pajarito Road, either from TA-3-130 or from TA-18. Operations at TA-3-130 ceased when this facility closed in July 2001, so the largest dose to a member of the public this year was from TA-18 to a person on Pajarito Road (Section C.3. of this chapter).

To estimate the dose to the public, we combine the measurements of gamma and neutron dose with an occupancy factor. We follow standard guidance and assume continuous occupancy (i.e., 24 hours per day and 365 days per year) for residences and places of business. For locations such as Pajarito Road, where exposure is periodic, we multiply the measured dose by an occupancy factor of 1/16 (NCRP 1976.)

b. Airborne Radioactivity (Inhalation Pathway). At distances more than a few hundred meters from LANL sources, the dose to the public is almost

entirely from airborne radioactive material. Whenever possible, we use the direct measurements of airborne radioactivity concentrations measured by AIRNET and reported in Chapter 4, Section A. All of these measurements result in an annual dose to a member of the public that is less than 0.1 mrem. Where local concentrations are too small to measure, we calculate the doses using the standard model, CAP88, that combines source-term information with meteorological data to estimate where the released radioactive material went.

AIRNET does not measure some of the nuclide emissions from the Los Alamos Neutron Science Center (LANSCE). These emissions are measured at the stacks (Chapter 4, Section B), and we use CAP88 to calculate the resulting doses (Chapter 3, Section C). Because the radioactive half-lives are short, these doses decrease steeply with distance; e.g., the annual dose is 1.4 mrem at East Gate 1 km to the north of LANSCE and is less than 0.01 mrem at a location in Los Alamos 5 km to the west-northwest.

c. Food (Ingestion Pathway). A food type is considered a potentially significant exposure pathway if it contains radioactive material that is detected above background concentrations. Chapter 6 reports the measurements of the radioactive content of foods, and Table 3-1 summarizes the resulting ingestion doses. These measurements of radioactive content in food include background radioactivity (including man-made radioisotopes in fallout).

The general process for calculating ingestion doses is to multiply the amount of each radionuclide in a food product by a dose conversion factor for that radionuclide (DOE 1988b). We collected and analyzed many different types of food products for their radionuclide content. Table 3-1 lists the doses from ingesting unit quantities of these foods, but we did not correct them for background or regional concentrations.

The dose from consuming a pound of elk or deer bone is similar to the amounts reported in previous years, less than 0.06 mrem. This dose is almost entirely from strontium-90, which is like calcium and so concentrates in bone. The amount of strontium-90 in animals collected near LANL is not statistically different from those collected far from LANL, which indicates that the strontium-90 is mostly attributable to global fallout and not to LANL.

The dose from consuming a pound of fish is less than 0.001 mrem and is also mostly from strontium-90. Because the fish downstream of LANL do not have significantly higher concentrations than fish upstream,

3. Environmental Radiological Dose Assessment

Table 3-1. Ingestion Doses from Foods Gathered or Grown in the Area during 2001

	Dose per Pound (mrem/lb)	2s ^a (mrem/lb)
Deer		
Regional	4.1E-4 muscle	3.8E-4
	4.0E-2 bone	1.4E-2
San Ildefonso Pueblo	1.09E-04 muscle	1.42E-04
	3.41E-02 bone	6.59E-03
Tesuque Pueblo	1.32E-04 muscle	1.92E-04
	2.46E-02 bone	4.70E-03
Elk		
Regional Background	5.12E-04 muscle	6.34E-04
	5.92E-02 bone	3.86E-02
Regional Background near LANL	6.13E-05 muscle	6.71E-04
	5.23E-02 bone	4.00E-02
Fish		
Game Fish Upstream	6.00E-04	2.90E-04
Game Fish Downstream	7.20E-04	4.60E-04
Nongame Fish Upstream	9.10E-04	3.30E-04
Nongame Fish Downstream	8.70E-04	4.40E-04
Prickly Pear		
Regional Background	2.69E-03	4.32E-03
Los Alamos	7.00E-03	4.07E-03
San Ildefonso	7.10E-03	4.74E-03
Produce		
Regional Background	2.40E-04	2.12E-04
On LANL	1.70E-04	2.89E-04
Los Alamos	5.02E-04	4.15E-04
White Rock	3.92E-04	6.63E-04
Cochiti	4.28E-04	5.15E-04
San Ildefonso	2.75E-04	2.78E-04

^aThis column is the two-standard-deviation (2s) uncertainty. Where the dose is greater than 2s, the dose is considered statistically significant with 95% confidence and is indicated by bold text.

3. Environmental Radiological Dose Assessment

the strontium-90 is mostly attributable to global fallout and not to LANL.

This year, local samples of prickly pear contained more strontium-90 than regional samples; however, last year's regional samples contained more than either regional or local samples collected this year. These fluctuations appear to be within statistical variability and do not point to LANL as the source of the strontium-90. The prickly pear samples also contain a small but measurable concentration of uranium, but the isotopic ratios are consistent with natural uranium. We conclude that the prickly pear data do not indicate a significant dose attributable to LANL.

The dose from consuming a pound of vegetable or fruit produce from Los Alamos is estimated as about 0.0005 mrem per pound (the statistical significance is marginal). Most of this dose is again from strontium-90, which is most likely from global fallout. Fallout is scavenged by rainfall and therefore tends to be higher in regions of higher rainfall. We conclude it is probably not attributable to LANL. Whatever the origin, the average resident of Los Alamos who consumes 30 pounds of local produce per year would receive an annual dose of 0.015 mrem from this produce.

In summary, we conclude that the LANL contribution to the food dose is too small to measure and is much less than 0.1 mrem per year.

d. Water (Ingestion Pathway). Kraig and Gladney (2001) collected 30 tap water samples: 10 from Los Alamos; 10 from White Rock; 3 from Santa Fe; 2 from Española; and one each from Chimayo, Dixon, El Rito, Jemez, and Pojoaque. Each sample was analyzed for tritium, strontium-90, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239, and americium-241. For each radionuclide, the minimum detectable activity was sufficient to measure a potential dose less than 0.1 mrem per year.

At all locations and for all radionuclides except uranium, the doses were much less than 0.1 mrem per year. Natural uranium in the drinking water contributes a dose of about 0.1 mrem per year in Los Alamos County and somewhat more in Santa Fe and the Rio Grande valley.

In summary, we conclude that the LANL contribution to the drinking-water dose is too small to measure and is much less than 0.1 mrem per year.

e. Soil (Direct Exposure Pathway). We report measurements of radionuclide concentrations in surface soil in Chapter 6. These radionuclides in soil

contribute to dose through the air pathway, which is evaluated in Section B.2.b; through ingestion of food, which is evaluated in Section B.2.c; and through gamma radiation, which is evaluated in Section B.2.a and is further evaluated here.

Almost all the gamma radiation from soils is from cesium-137, which contributes less than 1 mrem per year. The other radionuclides contribute much less than 0.1 mrem per year.

Cesium-137 is a product of global fallout from nuclear weapons tests and is found worldwide in concentrations similar to those reported in Chapter 6. Two publications, Fresquez et al., 1996, and Fresquez et al., 1998, conclude that the concentrations reported in Chapter 6 are the result of global fallout. Fallout is scavenged by rainfall, so the concentrations are higher in regions where the rainfall is higher; and, for this reason, the concentrations are higher in Los Alamos County than in the Rio Grande valley. In the *Environmental Surveillance Report* for 2000 (ESP 2001), we reported a 2000 dose of 0.14 mrem from radionuclides in soil, with a reported 1 standard deviation of 0.4 mrem. This dose was calculated in the past by subtracting regional soil concentrations from local soil concentrations and modeling the net difference using a modified residential scenario. The resulting dose was very conservative, statistically not significant, and does not contribute measurably to the annual dose to the MEI.

In summary, we conclude that the LANL contribution to dose from soil is too small to measure and is less than 0.1 mrem per year.

f. Release of Property. The Laboratory releases surplus items of property to the general public. Laboratory Implementation Requirement LIR-402-700-01.0, "Occupational Radiation Protection. Chapter 14, Part 3. Releasing Items," describes the requirements for release of such property. In keeping with the principle of maintaining radiation dose levels to "As Low As Reasonably Achievable," it is Laboratory policy to not release any property with residual radioactivity. Therefore, the general public receives no additional dose through the release of personal property for uncontrolled use by the general public.

C. Dose Calculations and Results

1. Population within 80 km

We used the local population distribution (Figure 3-1) to calculate the dose from Laboratory operations

3. Environmental Radiological Dose Assessment

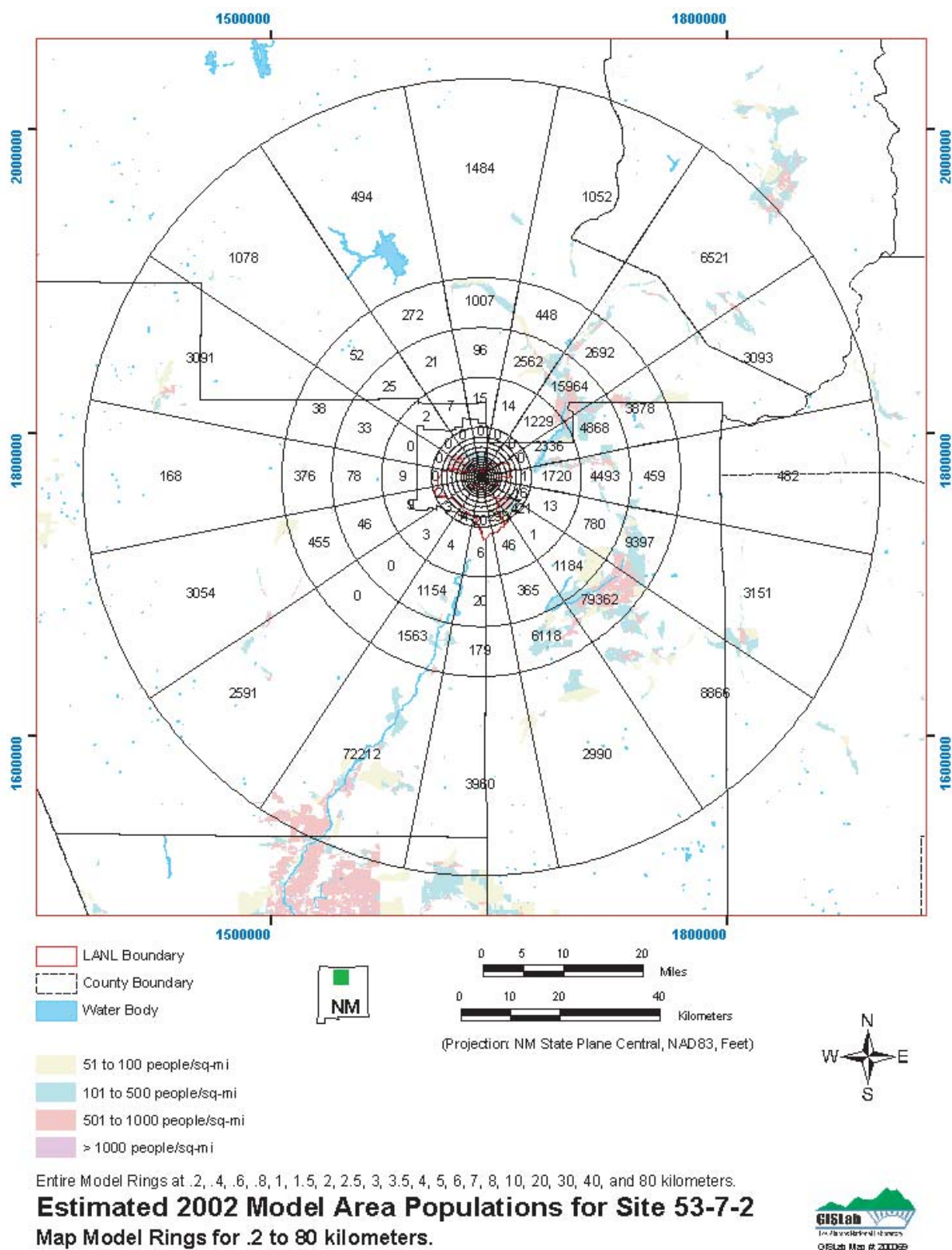


Figure 3-1. Estimated population around Los Alamos National Laboratory.

3. Environmental Radiological Dose Assessment

during 2001 to the population within 80 km (50 miles) of LANL. Approximately 277,000 persons live within an 80-km radius of the Laboratory. We used county population estimates provided by the University of New Mexico Bureau of Business and Economic Research (BBER). These statistics are available at <http://www.unm.edu/~bber/>.

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL; for example, if two persons each receive 3 mrem, the collective dose is 6 person-mrem. This dose results from airborne radioactive emissions; other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88, an atmospheric dispersion and dose calculation computer code.

The 2001 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 1.6 person-rem, which compares with 1 person-rem reported for 2000. This increased dose resulted from increased stack releases as described in Chapter 4, Section B. Tritium increased because of decommissioning TA-33 and TA-41 and also because of an unplanned tritium release from the Weapons Engineering Tritium Facility (WETF) on January 31, 2001. Also, LANSCE emissions increased because of changes to the 1L-target water-cooling system. Tritium contributed about 73% of the dose; short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 26%; and plutonium, uranium, and americium contributed less than 1%.

No observable health effect is expected from these doses.

2. Off-Site MEI

The off-site MEI is a hypothetical member of the public who, while not on DOE/LANL property, received the greatest dose from LANL operations. The location of the off-site MEI was at East Gate along State Road 502 entering the east side of Los Alamos County. East Gate is normally the location of greatest exposure because of its proximity to LANSCE. During LANSCE operations, short-lived positron emitters such as carbon-11, nitrogen-13, and oxygen-15 are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

As discussed in Chapter 4, Section B, the LANSCE stack emissions were larger this year as a result of

changes to the 1L-target water-cooling system. Therefore, the MEI dose was 1.9 mrem this year compared with 0.64 mrem in 2000.

We modeled the dose from LANSCE and from the LANL stacks using CAP88. The CAP88-modeled doses were 1.4 mrem from the LANSCE stack, 0.1 mrem from LANSCE diffuse emissions, 0.1 mrem from the tritium stacks, and 0.2 mrem from other LANL stacks. To this total, we add 0.1 mrem from the radionuclides measured at the AIRNET station, although this is primarily from tritium, which has already been accounted for in the CAP88 model (Jacobson 2002).

The total annual dose, 1.9 mrem, is far below the applicable standards, and we conclude it causes no observable health effects.

3. On-Site MEI

The on-site MEI is a member of the public on Pajarito Road who passes LANL TA-18. Dosimeters that are sensitive to neutron and photon radiation are located on Pajarito Road. We collected data continuously throughout 2001 (Chapter 4, Section C), and these data allow us to calculate doses that might have been received by members of the public. After subtracting the dose from natural background, the total dose (during 24 hours a day and 365 days a year) was 67 mrem. Following the guidance of the National Council on Radiation Protection and Measurements (NCRP 1976), we multiplied this total by 1/16 to account for occupancy (an occupancy factor of 1/16 corresponds to an average of half an hour of exposure every 8-hour workday). This calculation yields a maximum dose of 4.2 mrem to a member of the public during 2001.

We report this dose as a conservative upper bound of the doses that people passing near this facility frequently might have received. All other pathways, including CAP88 calculations for the air pathway, add less than 0.1 mrem to the calculated dose. This dose is about 4% of the DOE public all-pathway dose limit of 100 mrem.

4. Doses in Los Alamos and White Rock

In this section, we discuss the doses to residents in Los Alamos and White Rock. We used the AIRNET data (reported in Chapter 4, Section A) to calculate the average air concentrations for the 21 perimeter stations near Los Alamos and White Rock and subtracted the average of the concentrations at the 4 regional stations.

3. Environmental Radiological Dose Assessment

These concentrations were converted to doses using the factors in DOE 1988b, assuming a breathing rate of 1 m³/hr, and continuous occupancy. To these doses, we added the contributions from LANSCE, calculated using CAP88 for two representative locations: 5 km west-northwest of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

a. Los Alamos. During 2001, the contributions to the dose at an average Los Alamos residence were 0.006 mrem from LANSCE, 0.005 mrem from plutonium, 0.003 mrem from americium, and 0.003 mrem from tritium; these add to 0.017 mrem. All other nuclides contribute less than 0.001 mrem.

b. White Rock. During 2001, the contributions to the dose at an average White Rock residence were 0.009 mrem from LANSCE, 0.001 mrem from plutonium, 0.001 mrem from americium, and 0.002 mrem from tritium; these add to 0.013 mrem. All other nuclides contribute less than 0.001 mrem.

See Section B.2 in this chapter for a discussion of the contributions from direct radiation, food, water, and soil; each was too small to measure and less than 0.1 mrem. Therefore, the total annual dose from all pathways was much less than 0.4 mrem.

5. Acid Canyon

The south fork of Acid Canyon was remediated from September 12 through November 9, 2001. Both the DOE Oversight Bureau of the New Mexico Environment Department (NMED) and the contractor, Washington Group International Inc. (WGII), collected air samples during the remediation activities. From these results, we calculate the dose at the nearest residence, 170 m north of the work site.

NMED measured 3.6E-14 Ci/m³ of transuranics (primarily plutonium-239) at a location within the roped-off work site and about 10 m north of the main work activities. This measurement was made during two workweeks of 40 hours each. We take this as the concentration for the full 336 work hours and calculated 8.7E-15 Ci/m³ averaged over the 1392 hours from September 12 to November 9. Also, WGII measured the following transuranic concentrations averaged over 1392 hours: 2.4E-15 Ci/m³ at 20 m, 3.3E-14 Ci/m³ at 5 m, and 6.9E-14 Ci/m³ at 3 m. These concentrations are more than two orders of magnitude below the occupational standard of 6E-12 Ci/m³ for class-Y transuranics.

These four concentrations are proportional to $x^{-1.8}$, where x is the average distance from the work

activities to the air sampler. This model corresponds to the prediction by the CAP88 atmospheric-dispersion program for class-C atmospheric stability. This model predicted that the average concentration at the nearest residence was 5E-17 Ci/m³. The estimate is conservative because it applies to smooth and flat terrain, whereas the trees and canyon walls reduce the concentration. For comparison, the CALPUFF program calculated an average concentration of 2.5E-17 Ci/m³ at the residence.

These concentrations are well below the EPA standard of 2E-15 Ci/m³. The dose to a member of the public who breathes 5E-17 Ci/m³ of transuranics for 1392 hours is 0.04 mrem, which is well below the 10-mrem dose limit allowed by EPA regulations.

6. Potential Dose Implications in the Aftermath of the Cerro Grande Fire

The burning of many acres of trees and ground cover during the Cerro Grande fire created the possibility of enhanced flooding in the canyons draining the east-facing side of the Jemez Mountains. Several of these watersheds (Los Alamos, Mortandad, and to a lesser extent Pajarito) have residual contamination from LANL operations. However, during the past 50 years or so, radioactive fallout (from worldwide uses of radioactive materials) has accumulated in soils, vegetation, and duff and represents a much larger source term available for mobilization by rainfall and/or flooding.

Our analysis considers two principal exposure scenarios: (1) to a resident who may have lived near contaminated sediments transported by and deposited from post-Cerro Grande runoff and (2) to individuals who may have been exposed to or used Rio Grande water contaminated by runoff events.

a. Exposure Assessment for Lower Los Alamos Canyon. During late 2001, rainstorms caused runoff throughout the Los Alamos Canyon watershed, in particular in Pueblo Canyon on July 2. After that event, we collected samples from locations in the reach near Totavi from layers representing a variety of sediment sizes within the deposits to determine if radionuclide distributions had changed from the previous year. We compared post-fire and flooding 2000 and 2001 data from Totavi with those from a pre-fire reference site immediately upstream from Totavi and with background soils and sediment data from many areas believed to be independent of LANL impacts.

3. Environmental Radiological Dose Assessment

Our analysis of the 2001 data indicated that cesium-137 and americium-241 were the only radionuclides seen in the Totavi area that were above background and pre-fire concentrations. Therefore, we considered only these radionuclides in the radiological dose assessment of potential Cerro Grande impacts at Totavi. The average cesium-137 concentration near Totavi of was about 0.56 pCi/g above the pre-fire concentrations. Americium-241 occurred at 0.014 pCi/g above pre-fire concentrations.

Our scenario involves children playing in the stream area among potentially contaminated sediments (ESP 2001; Kraig et al., 2002). The children are assumed to spend 4.4 hours each day (EPA 1997, Table 5-4) in an area extending 300 meters along the stream with the floodplains and banks 5 meters on each side (10 m wide). Based on our observations of deposited ash, only about 600 m² of this 3,000-m² exposure unit contained contaminated sediments from the post-fire deposition. The scenario is presented according to the various exposure pathways that could have been significant.

Inhalation Pathway

While playing, the hypothetical children breathe at a rate of 1.9 m³ per hour. This rate is an average respiration level for children doing heavy activities (EPA 1997, Table 5-23). The dust in the air they breathe is assumed to come from the local (10-m × 300-m) area and does not mix with air outside the 3,000-m² area. For our calculations, we assumed 100 µg/m³, a value that we consider represents an upper limit. By multiplying the concentration of a contaminant in soil by the fraction of the area that was contaminated and the dust-loading value, we calculated the concentration in air of that contaminant.

After we calculate the air concentration for each radionuclide, we can calculate the inhalation dose associated with that radionuclide. We multiply the air concentration by the amount of air breathed, the exposure frequency (4.4 h/day), exposure duration (365 days), and then by an inhalation dose conversion factor (DOE 1988b) that tells how much dose is received for each intake of radioactive material.

Soil Ingestion Pathway

An ingestion rate of 200 mg/day (EPA 1997) is assumed. This rate is an upper estimate of the daily soil ingestion rate in that it assumes that all of the soil

the children ingested daily came from the stream area. Dose is then calculated as the product of the soil concentration, fraction of the area that is contaminated, fraction of time spent in the exposure area (4.4 h/d ÷ 24h/d), and ingestion dose conversion factors (DOE 1988b).

Direct Exposure Pathway

To calculate the exposure potential for this pathway, a RESRAD (Yu et al., 2001) run was performed. For the run, only the direct exposure pathway was used. The contamination was assumed to be 9 cm deep spread over a fraction (0.2) of the surface of a 3,000-m² circular area. We assumed the area to be circular, even though it is actually rectangular, because this maximizes the calculated direct exposure. A person is assumed to be in the area for 4.4 hours per day (EPA 1997, Table 5-4), unshielded from the radiation.

Dose Assessment for Lower Los Alamos Canyon

Table 3-2 presents the calculated radiological doses from the three exposure pathways. Because the concentration that would cause these dose increments persisted from 2000 into 2001, this year we calculated doses received on an annual basis. In both years, the calculated dose of 0.05 was negligible compared with dose limits established in DOE Order 5400.5.

These figures represent total effects from the Cerro Grande fire and include an increment from LANL-related contamination that cannot be measured.

b. Exposure Assessment for Rio Grande Water Users. This assessment parallels the evaluation of the 2000 post-fire data as described in ESP (2001) and Kraig et al. (2002).

To determine concentrations in the Rio Grande, we identified the data with the smallest differences between flow in the Rio Grande and canyons crossing

Table 3-2. Lower Los Alamos Canyon Annual Dose (mrem)

Exposure Pathway	2000	2001
Inhalation	0.000001	0.0004
Ingestion	0.0005	0.0012
Direct Penetrating Radiation	0.06	0.05
Total	0.06	0.05

3. Environmental Radiological Dose Assessment

LANL, used the ratio of the flows to calculate a minimum dilution factor, and multiplied the dilution factor times the maximum measured concentrations in storm water. The smallest difference in flows occurred on July 2, resulting in calculated dilution factors of 3.5.

Table 3-3 lists the maximum detected concentrations for these LANL canyon stations. Predicted maximums are reported for Guaje and LANL Canyons. Guaje Canyon is included here as a possible reference canyon to help interpret whether risks were strictly fire-related or had a possible LANL contribution. Guaje Canyon is far enough from LANL that sediment concentrations there do not show effects of LANL operations with the possible exception of plutonium-239 (Kraig et al., 2002).

Average and peak concentrations in unfiltered runoff leaving LANL in 2000 and 2001 were significantly greater than pre-fire levels for nearly every analyte during the months of June and July. The peak concentrations of these radionuclides increased by factors of about 2 (see Chapter 5).

c. Irrigation Scenario. Downstream from Cochiti Reservoir, people make considerable use of irrigation water that could have been contaminated by runoff since the Cerro Grande fire. Irrigation water drawn from the river during runoff events and spread on crop fields, fruit trees, or pasture may represent an exposure pathway to animals and eventually to humans.

ESP (2001) and Kraig et al. (2002) describe the input values for this scenario.

Assuming that the source of the flood runoff was LANL-affected canyons, we calculated the dose per irrigation event to be 0.1 mrem, approximately the same amount as last year. The dose from non-LANL-affected canyons was 0.09 mrem, about half of last year's estimate.

d. Drinking Water from, Swimming in, or Fishing in the Rio Grande. Assuming someone drank unfiltered water from the Rio Grande during the runoff with the highest radionuclide concentrations (Table 3-3), the calculated dose was 0.1 mrem per liter consumed from potential LANL-affected canyons and <0.01 mrem from canyons not affected by LANL operations. The largest dose contributor in either case would be plutonium-239, which had a higher concentration in 2001 runoff samples than in the 2000 samples.

If someone swam in the Rio Grande during the time of highest radionuclide concentration, his or her dose (based on input from canyons potentially affected by LANL) was calculated to be much less than 0.001 mrem/h as were calculations based on floodwater concentrations from non-Laboratory-affected canyons. Essentially all of this dose resulted from direct exposure to cesium-137.

We collected fish from Cochiti reservoir in 2000 and 2001 (after the fire) and compared their radionu-

Table 3-3. Rio Grande Runoff Comparison of 2001 Predicted Peak Concentrations in Unfiltered Water in Rio Grande Runoff

Analyte	LANL Pre-Fire Measurements ^{a,b}		2001 Post-Fire Predicted Maximums ^b		USGS 2001 Measurements
	Mean	Max	Guaje Canyon	LANL Canyons	
					Maximum
²⁴¹ Am	0.014	0.05	0.3	1.6	0.3
¹³⁷ Cs	1	1.1	2.9	5.1	NA ^c
²³⁸ Pu	-0.0002	0.02	0.2	0.2	0.02
^{239,240} Pu	0.02	0.15	1.1	25	0.04
⁹⁰ Sr	1	9	6.9	5.7	7.4

^aThese are summaries of measurements of the Rio Grande at the Frijoles inlet for the years 1993–1999.

^bAll units are pCi/L.

^cNA = not applicable.

3. Environmental Radiological Dose Assessment

slide contents with fish collected before the fire (1999). This comparison of radionuclide concentrations in fish collected before and after the fire shows that mean radionuclide concentrations in fish collected after the fire were statistically indistinguishable ($p < 0.05$) or lower than radionuclide concentrations in fish collected before the fire in 1999. Therefore, fish collected and eaten from the Rio Grande or Cochiti Reservoir during year 2001 would not have caused a fire-related dose increment.

e. Cattle Watering Scenario. Livestock watered in the Rio Grande after it was affected by storm water runoff. If these cattle drank contaminated water from the Rio Grande, their consumption by humans could result in a radiation dose. We can calculate this dose by evaluating the amount of radionuclides that the cattle consumed, how much of the radionuclides that were consumed ended up in the cattle tissues, and how much of these radionuclides would be passed to humans if they consumed the cattle (ESP 2001; Kraig et al., 2002). The dose calculations, for which some of the parameters are shown in Table 3-4, indicate that the potential LANL dose contribution from eating meat from cattle that have watered in the Rio Grande is less than 0.01 mrem.

f. Dose Summary and Perspective. The doses reported above for lower Los Alamos Canyon and for Rio Grande exposures were small for years 2000 and 2001. It is possible that the hypothetical individuals exposed at Totavi may also have been exposed to

some of the additional pathways described for the Rio Grande. If individuals were exposed to these various pathways, they can calculate their total dose from all pathways by adding the doses from the applicable exposure scenarios presented above. Future conditions and potential exposures will continue to be under evaluation and will be described as they are calculated.

To put some perspective on these doses, a person travelling on a two-hour flight in a jet airliner would receive approximately 1 mrem, and people living in the Los Alamos area receive about 360 mrem from natural sources each year. No health effects are expected from the short-term increase in radioactivity associated with the Cerro Grande fire.

D. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

This section discusses the LANL contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from radionuclides naturally in the environment. Doses from cosmic radiation range from 50 mrem per year at lower elevations near the Rio Grande to about 90 mrem per year in the mountains. Doses from terrestrial radiation range from about 50 to 150 mrem per year depending on the amounts of natural uranium, thorium, and potassium in the soil.

Table 3-4. Monthly Dose from Ingestion of Meat from Cattle that have Watered only in the Rio Grande and only while Runoff from LANL Canyons was Occurring

Radionuclide	Concentration in Rio Grande Water (pCi/L)	Transfer Factor (pCi/kg per pCi/day) ^a	Dose Conversion Factor (mrem/pCi) ^b	Effective Dose Equivalent (mrem)
⁹⁰ Sr	5.7	3.0 E-04	0.00013	0.00005
¹³⁷ Cs	5.1	2.0 E-02	0.00005	0.0012
²³⁸ Pu	0.2	5.0 E-07	0.0038	0.000000094
^{239,240} Pu	25	5.0 E-07	0.0043	0.000013
²⁴¹ Am	1.6	3.5 E-06	0.0045	0.0000062
Total				0.0013

^aKennedy and Strenge 1992, p. 6.29.

^bDOE 1988b.

3. Environmental Radiological Dose Assessment

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products, which contribute about 200 mrem per year. An additional 40 mrem per year results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and in all living cells.

In addition, members of the US population receive an average dose of 50 mrem per year from medical and dental uses of radiation, 10 mrem per year from man-made products such as stone or adobe walls, and less than 1 mrem per year from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the total annual dose from sources other than LANL is in the range of about 300–500 mrem. The estimated LANL-attributable 2001 dose to the on-site MEI, 4.2 mrem, is about 1% this dose.

E. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem). However, doses to the public from LANL operations are much smaller. According to the 1996 Position Statement of the Health Physics Society (HPS 1996): “Below 10 rem, risks of health effects are either too small to be observed or are non-existent.” Therefore, the doses reported here are not expected to cause observable health effects.

F. Estimating Radiological Dose to Nonhuman Biota

1. DOE Standard for Evaluating Dose to Aquatic and Terrestrial Biota

In June 2000, the DOE Air, Water, and Radiation Division (EH-412) issued interim DOE Technical Standard ENR-0011, entitled “A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota” (DOE 2000) (available at <http://homer.ornl.gov/oepal/public/bdac/>). The interim standard provides guidance for the evaluation of ionizing radiation doses to aquatic animals and terrestrial animals and plants. DOE sites can use this guidance to establish that site conditions are in compliance with established radiation dose limits for protection of nonhuman biota. DOE Order 5400.5 (DOE 1993) establishes a dose limit of 1 rad day⁻¹ (10 mGy day⁻¹) for protection of aquatic organisms. Based on this limit and a review of the radiation

protection literature, the DOE technical standard adopts biota dose limits as follows:

- aquatic animals: absorbed dose that does not exceed 1 rad day⁻¹
- terrestrial plants: absorbed dose that does not exceed 1 rad day⁻¹
- terrestrial animals: absorbed dose that does not exceed 0.1 rad day⁻¹

These limits are based on concerns for limiting reproductive impairment in free-living populations of organisms. Although the goal of the standard is to provide protection for population viability, population dose limits are inferred from observations of individual impairment among the most radiosensitive organisms. These dose limits for protection of populations ensure that there would be no observable adverse effects to members of populations for which protection of individual viability and productivity is of concern. Such considerations are of interest when evaluating impacts to threatened, endangered, or otherwise protected species of biota.

2. Comparison of Media Concentrations to Biota Concentration Guides (BCGs)

The DOE Biota Dose Assessment Team calculated Biota Concentration Guides (BCGs) for screening environmental media to determine the potential for doses to aquatic and terrestrial biota that exceed the prescribed limits. The BCGs are based on the dose limits given above and assume that the daily dose is averaged over a year. See DOE (2000) Module 3 for the input parameters and equations used in derivation of the BCGs.

For aquatic and riparian (streamside) organisms, we used maximum media concentrations for persistent surface water and sediments (Tables 5-2 and 5-14) to compare with applicable BCGs (found in DOE 2000). The values for persistent surface waters were used because runoff (snowmelt and storm water) is generally not persistent enough to support aquatic or wetland/riparian communities. Thus, exposure to aquatic organisms would be dominated by contaminant levels found in persistent surface water bodies. We compared maximum media concentrations in 2001 with applicable BCGs and calculated the ratios (partial fractions) of measured concentrations to the guides (Table 3-5). The sum of these ratios is 0.38, indicating that the total dose to aquatic organisms or riparian

Table 3-5. Comparison of Media Concentrations to Biota Concentration Guides (BCG) for Protection of Aquatic/Riparian Systems

Nuclide	Water, Aquatic/Riparian Systems			Sediment, Aquatic/Riparian Systems			Water & Sediment Sum of Fractions	Organism Responsible for the Limiting Dose	
	Water BCG	Site	Partial	Sediment BCG	Site	Partial		Water	Sediment
	pCi/L	Data ^a	Fraction	pCi/g	Data ^b	Fraction			
²⁴¹ Am	4.E+02	6.5E+00	1.5E-02	5.E+03	1.3.E+01	2.6E-03	1.7E-02	Aquatic Animal	Riparian Animal
¹³⁷ Cs	4.E+01	1.1E+01	2.6E-01	3.E+03	2.8.E+01	9.3E-03	2.7E-01	Riparian Animal	Riparian Animal
³ H	3.E+08	3.1E+03	1.2E-05	4.E+05	3.8.E-03	9.5E-09	1.2E-05	Riparian Animal	Riparian Animal
²³⁹ Pu	2.E+02	1.8E+00	9.6E-03	6.E+03	1.3.E+01	2.2E-03	1.2E-02	Aquatic Animal	Riparian Animal
⁹⁰ Sr	3.E+02	1.2E+01	4.3E-02	6.E+02	1.8.E+01	3.0E-02	7.3E-02	Riparian Animal	Riparian Animal
²³⁴ U	2.E+02	8.5E-01	4.2E-03	5.E+03	1.8.E+00	3.6E-04	4.6E-03	Aquatic Animal	Riparian Animal
²³⁵ U	2.E+02	4.9E-02	2.3E-04	4.E+03	1.3.E-01	3.3E-05	2.6E-04	Aquatic Animal	Riparian Animal
²³⁸ U	2.E+02	5.0E-01	2.2E-03	2.E+03	2.0.E+00	1.0E-03	3.2E-03	Aquatic Animal	Riparian Animal
Sum of fractions for radionuclides in water			➡ 3.3E-01	Sum of fractions for radionuclides in sediment			➡ 4.5E-02	3.8E-01	

^aMaxima from Table 5-2.^bMaxima from Table 5-14.

3. Environmental Radiological Dose Assessment

organisms is below the dose limit of 1 rad day⁻¹. The primary contributor to the dose here is cesium-137 in waters just downstream from the outfall at TA-50 that discharges effluent from the Laboratory's Radioactive Liquid Waste Treatment Facility. Concentrations of radionuclides in surface waters elsewhere are considerably lower by several orders of magnitude. Overall, releases of radionuclides to surface waters and sediments have not led to doses that exceed limits for the protection of aquatic and riparian animals.

Table 3-6 presents the results of comparing measured maximum soil concentrations and wildlife drinking water concentrations with BCGs for protection of terrestrial biota. The limiting receptor in this case is the generic terrestrial animal for all radionuclides. The sum of the partial fractions in the terrestrial case is 0.05, well below the value of 1, indicating that terrestrial systems are very unlikely to receive exposures leading to exceedance of the dose limit.

Table 3-6. Comparison of Media Concentrations to Biota Concentration Guides (BCG) for Protection of Terrestrial Systems

Nuclide	Water, Terrestrial Systems			Sediment, Terrestrial Systems			Water & Soil Sum of Fractions	Organism Responsible for the Limiting Dose	
	Water BCG	Site	Partial	Soil BCG	Site	Partial		Water	Sediment
	pCi/L	Data ^a	Fraction	pCi/g	Data ^b	Fraction			
²⁴¹ Am	2.E+05	6.5E+00	3.3E-05	4.E+03	1.8E-02	4.5E-06	3.7E-05	Terrestrial Animal	Terrestrial Animal
¹³⁷ Cs	6.E+05	1.1E+01	1.8E-05	2.E+01	6.1E-01	3.1E-02	3.1E-02	Terrestrial Animal	Terrestrial Animal
³ H	2.E+07	3.1E+03	1.6E-04	6.E+04	2.2E-01	3.7E-06	1.6E-04	Terrestrial Animal	Terrestrial Animal
²³⁹ Pu	2.E+05	1.8E+00	9.0E-06	6.E+03	3.9E-02	6.5E-06	1.6E-05	Terrestrial Animal	Terrestrial Animal
⁹⁰ Sr	5.E+04	1.2E+01	2.4E-04	2.E+01	2.7E-01	1.4E-02	1.4E-02	Terrestrial Animal	Terrestrial Animal
²³⁴ U	4.E+05	8.5E-01	2.1E-06	5.E+03	1.6E+00	3.2E-04	3.2E-04	Terrestrial Animal	Terrestrial Animal
²³⁵ U	4.E+05	4.9E-02	1.2E-07	3.E+03	1.5E-01	5.0E-05	5.0E-05	Terrestrial Animal	Terrestrial Animal
²³⁸ U	4.E+05	5.0E-01	1.3E-06	2.E+03	1.9E+00	9.5E-04	9.5E-04	Terrestrial Animal	Terrestrial Animal
Sum of fractions for radionuclides in water			4.58E-04	Sum of fractions for radionuclides in soil			4.5E-02	4.6E-02	

^aMaximum values from Table 5-2.^bMaximum values from Table 6-1.

3. Environmental Radiological Dose Assessment

G. References

- DOE 1988a: US Department of Energy, "External Dose Conversion Factors for Calculating Dose to the Public," US Department of Energy report DOE/EP-0070 (July 1988).
- DOE 1988b: US Department of Energy, "Internal Dose Conversion Factors for Calculating Dose to the Public," US Department of Energy report DOE/EP-0071 (July 1988).
- DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).
- DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order DOE 5400.5 (January 1993).
- DOE 2000 (Proposed): US Department of Energy "A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota," US Department of Energy Technical Standard ENVR-011 (June 2000). [available at <http://homer.ornl.gov/oepa/public/bdac/>].
- EPA 1986: US Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants," Code of Federal Regulations, Title 40, Part 61 (1986).
- EPA 1988: Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," EPA-520/1-88-020, Federal Guidance Report No. 11 (September 1988).
- EPA 1993: Environmental Protection Agency, "External Exposure to Radionuclides in the Air, Water, and Soil," EPA-402-R-93-081, Federal Guidance Report No. 12, (September 1993).
- EPA 1997: Environmental Protection Agency, "Exposure Factors Handbook," EPA/600/C-99/001 (August 1997).
- EPA 2000: US Environmental Protection Agency, "Primary Drinking Water Regulations; Radionuclides; Final Rule," Code of Federal Regulations, Title 40, Parts 9, 141, and 142 (December 2000).
- ESP 2001: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory report LA-13861-ENV (October 2001).
- Fresquez et al., 1996: P. R. Fresquez, M. A. Mullen, J. K. Ferenbaugh, and R. A. Perona, "Radionuclides and Radioactivity in Soils within and around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons," Los Alamos National Laboratory report LA-13149-MS (April 1996).
- Fresquez et al., 1998: P. R. Fresquez, D. A. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils Collected from within and around Los Alamos National Laboratory: 1974–1996," *Journal of Environmental Science and Health* **A33** (2), 263–278 (1998).
- HPS 1996: Health Physics Society, "Radiation Risk in Perspective," Health Physics Society Position Statement, HPS Newsletter (March 1996).
- Jacobson 2002: Keith W. Jacobson, 2002, "U.S. DOE Report: 2001 LANL Radionuclide Air Emissions," Los Alamos National Laboratory report LA-13957-PR (2002).
- Kennedy and Streng 1992: W. E. Kennedy, Jr., and D. L. Streng, "Residual Radioactive Contamination from Decommissioning - Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent: Final Report," US Nuclear Regulatory Commission report NUREG/CR-5512-V1 (October 1992).
- Kraig and Gladney 2001: David H. Kraig and Ernest S. Gladney, "Tap Water Sampling and Analysis during Calendar Year 2001 for Calculation of Radiological Dose to the Public," Los Alamos National Laboratory document LA-UR-01-6643 (2001).

3. Environmental Radiological Dose Assessment

- Kraig et al., 2002: D. H. Kraig, R. Rytty, D. Katzman, T. Buhl, B. Gallaher, and P. Fresquez, "Radiological and Nonradiological Effects after the Cerro Grande Fire," Los Alamos National Laboratory report LA-13914 (March 2002).
- NCRP 1975: National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," National Council on Radiation Protection and Measurements report 45 (November 1975).
- NCRP 1976: National Council on Radiation Protection and Measurements, "Structural Shielding and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV, Recommendations of the National Council On Radiation Protection and Measurements," National Council on Radiation Protection and Measurements report 49 (1976).
- NCRP 1987a: National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements report 93 (September 1987).
- NCRP 1987b: National Council on Radiation Protection and Measurements, "Exposure of the Population in the United States and Canada from Natural Background Radiation," National Council on Radiation Protection and Measurements report 94 (December 1987).
- NRC 1977: Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," Nuclear Regulatory Commission Report, Regulatory Guide 1.109 (October 1977).
- Yu et al., 2001: C. Yu, A. J. Zielen, J. J. Cheng, D. J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo III, W. A. Williams, and H. Peterson, "User's Manual for RESRAD Verion 6," Argonne National Laboratory report ANL/EAD-4 (July 2001).

4. Air Surveillance





4. Air Surveillance

contributing authors:

*Jean Dewart, Craig Eberhart, Dave Fuehne, Ernie Gladney, Scott Johnson
Angelique Luedeke, Mike McNaughton, Scott Miller, Terry Morgan*

Abstract

Los Alamos National Laboratory (LANL or the Laboratory) operations emit radioactive and nonradioactive air pollutants and direct penetrating radiation into the atmosphere. Air surveillance at Los Alamos includes monitoring emissions, ambient air quality, direct penetrating radiation, and meteorological parameters to determine the air quality impacts of Laboratory operations.

The ambient air quality in and around the Laboratory meets all Environmental Protection Agency (EPA) and Department of Energy (DOE) standards for protecting the public and workers.

Radioactive air emissions, totaling 15,500 Ci, were higher in 2001 than in 2000. This change was primarily due to increased emissions from the Los Alamos Neutron Science Center (LANSCE) and from an unplanned release of tritium gas from the Weapons Engineering Tritium Facility (WETF). Although LANSCE operated for a similar number of hours in 2001 and 2000, a change in the beam target operations produced higher emissions (5940 Ci in 2001 compared with 690 Ci in 2000). The unplanned release of about 7600 Ci of tritium from WETF occurred when a container of legacy waste failed during processing. There were no unplanned releases of radionuclides to the air that required reporting to the EPA or the New Mexico Environment Department (NMED).

Radioactive ambient air quality as monitored by AIRNET was similar to 2000. Highest air concentrations caused by Laboratory operations were measured at Technical Area (TA) 54.

The Air Quality Group (ESH-17) changed methods for recovering tritium from spiked quality control samples to reflect actual AIRNET sampling practices. This change identified the need to correct for the dilution by bound water in the silica gel and thus increased calculated tritium concentrations.

ESH-17 investigated several instances of elevated air concentrations in 2001. Elevated tritium concentrations were measured at several stations from operations at TAs-16, -21, -33, -41, and -54. These elevated air concentrations were the result of routine Laboratory operations. Elevated plutonium concentrations were measured at TA-54. In 2001, measurements at a number of on-site and off-site locations found excess depleted uranium. The loss of ground cover and vegetation resulting from the Cerro Grande fire in 2000, combined with below average precipitation, may have increased resuspension of depleted uranium. None of these elevated air concentrations exceeded applicable DOE or EPA protection standards for workers or the public.

ESH-17 established three nonradioactive air-monitoring stations during 2001 to evaluate air concentrations of metals, volatile organic compounds, and particulate matter. The monitoring stations were designed and located to establish background levels of constituents/pollutants in the surrounding communities and, if possible, to determine any Laboratory impacts. The metals data were consistent with expected values that would occur because of the resuspension of local soils. Particulate matter measurements were consistent with historical measurements.

Quarterly concentrations of beryllium were similar to 2000. Concentrations were consistent with values expected because of resuspension of naturally occurring beryllium in soils. The dustiest locations—the Los Alamos County Landfill, Jemez Pueblo, and TA-54—had the highest measured concentrations. Special short-term beryllium samples were taken to monitor 3 high-explosives test shots. Three on-site air samples contained elevated beryllium and uranium based on comparisons with average air concentrations measured on non-test-shot days.

During 2001, measurements of direct penetrating radiation at most locations were similar to 2000 values. Highest gamma doses were measured at locations on-site at TA-54, Area G; TA-3-

4. Air Surveillance

130; and the LANSCE lagoons. Measurements at several TA-54, Area G, locations were similar to 2000 representing the increase in radioactive waste currently stored aboveground. We report one full year of albedo dosimeter (neutron) measurements, taken on-site in the vicinity of TA-18 and TA-3-130. The calibration facility moved to a location distant from public exposure (TA-36) in August 2001 from its former location at TA-3-130.

Los Alamos weather for 2001 continued a four-year trend of warm temperatures and a dryer-than-normal climate. The total precipitation in 2001 was 79% of normal at 14.4 inches. These warm and dry conditions do not appear to be unusual with respect to the 70-year climate history. An inch of rain on July 2 washed out a road and flooded several homes in Los Alamos.

ESH-17 maintains a vigorous quality assurance program. Analytical laboratories met EPA and LANL requirements for quality control samples during 2001.

To Read About . . .	Turn to Page . . .
<i>Ambient Air Sampling</i>	84
<i>Stack Air Sampling for Radionuclides</i>	93
<i>Gamma and Neutron Radiation Monitoring Program</i>	96
<i>Nonradioactive Emissions Monitoring</i>	98
<i>Meteorological Monitoring</i>	102
<i>Quality Assurance Program in the Air Quality Group</i>	105
<i>Unplanned Releases</i>	107
<i>Special Studies</i>	107
<i>Glossary of Terms</i>	547
<i>Acronyms List</i>	557

A. Ambient Air Sampling (Craig Eberhart)

1. Introduction

The radiological air-sampling network, referred to as AIRNET, at Los Alamos National Laboratory (LANL or the Laboratory) measures environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include plutonium, americium, uranium, tritium, and activation products. Each AIRNET station collects two types of samples for analysis: a total particulate matter sample and a water vapor sample.

Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the Laboratory's air sampling program. Fallout from past atmospheric nuclear weapons tests by several countries, natural radioactive constituents in particulate matter such as uranium and thorium, terrestrial radon diffusing out of the earth and its subsequent decay products, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic

radiation and common atmospheric gases) make up most of the regional airborne radioactivity. Table 4-1 summarizes regional levels of radioactivity in the atmosphere for the past five years, which can be useful in interpreting current air sampling data.

Particulate matter in the atmosphere is primarily caused by aerosolized soil, which is dependent on meteorological conditions. Windy, dry days can increase soil entrainment, but precipitation (rain or snow) can wash particulate matter out of the air. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Natural events can also have major impacts: during 2000, a major forest fire (the Cerro Grande fire) dramatically increased short-term ambient concentrations of particulate matter. The 2000 Environmental Surveillance Report (ESP 2001) contained a discussion of the ambient measurements associated with this fire.

The Air Quality Group (ESH-17) compares ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental compliance standards or workplace exposure standards depending

on the location of the sampler. We usually compare annual concentrations in areas accessible to the public with the 10-mrem equivalent concentration established by the Environmental Protection Agency (EPA 1989) and published in 40 CFR Part 61 Appendix E Table 2—"Concentration Levels for Environmental Compliance." Concentrations in controlled access areas are usually compared with Department of Energy (DOE) Derived Air Concentrations (DAC) for workplace exposure (DOE 1988a) because access to these areas is generally limited to workers with a need to be in the controlled area.

2. Air Monitoring Network

During 2001, the Laboratory operated more than 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as regional; pueblo; perimeter; quality assurance (QA); Technical Area (TA) 21; TA-15 and TA-36; TA-54 (Area G); or other on-site locations. Four regional sampling stations determine regional background and fallout levels of atmospheric radioactivity. These regional stations are located in Española and El Rancho and at two locations in Santa Fe. The pueblo monitoring stations are located at San Ildefonso and Jemez Pueblos. In 2001, more than 20 perimeter stations were within 4 km of the Laboratory boundary.

Because maximum concentrations of airborne releases of radionuclides would most likely occur on-site, more than 20 stations are within the Laboratory boundary. For QA purposes, two samplers are collocated as duplicate samplers, one at TA-54 and one at TA-49. In addition, a backup station is located at East Gate. Stations can also be classified as being inside or outside a controlled area. A controlled area is a posted area that potentially has radioactive materials or elevated radiation fields (DOE 1988a). The active waste disposal site at TA-54, Area G, is an example of a controlled area.

We added three samplers to the network in 2001: station 68 Airport Road replaced station 71 at TA-21 to provide better measurements downwind from TA-21; station 53 was installed at TA-54, MDA H, to provide tritium data for the Environmental Restoration (ER) program; and station 80 was added at the request of New Mexico Oversight Bureau to provide additional measurements near the burned areas above the Los Alamos town site.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures. Generally, each AIRNET sampler continuously collects particulate matter and water vapor samples for approximately two weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m³ per minute. The vertically mounted canisters each contain about 135 grams of silica gel with an airflow rate of about 0.0002 m³ per minute; the gel collects the water vapor samples. This silica gel is dried in a drying oven before use in the field to remove most residual water. The gel is a desiccant that removes moisture from the sampled air; the moisture is then distilled, condensed, collected as a liquid, and shipped to the analytical laboratory. The AIRNET project plan (ESH-17 2000) and the numerous procedures through which the plan is implemented provide details about the sample collection, sample management, chemical analysis, and data management activities.

b. Data Management. Using a palm-held microcomputer, we recorded the 2001 sampling data, including timer readings, volumetric airflow rates at the start and stop of the sampling period, and comments pertaining to these data, electronically in the field. We later transferred these data to an electronic table format within the AIRNET Microsoft Access database. We also received the analytical data described in the next section in electronic form and loaded them into the database.

c. Analytical Chemistry. A commercial laboratory analyzed each 2001 particulate matter filter for gross alpha and gross beta activities. These filters were also grouped across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. For 2001, clumps ranged from six to nine filters. Gamma-emitting radionuclides were also measured at each Federal Facilities Compliance Agreement station by grouping the filters collected each quarter. We combined half-filters from the six or seven sampling periods at each site during the quarter to prepare a quarterly composite for isotopic analyses for each AIRNET station. These composites were dissolved, separated chemically, and then analyzed for isotopes of americium, plutonium, and uranium using alpha spectroscopy. Every two weeks, water was distilled from the silica gel that had been deployed to the field. A commercial laboratory analyzed this distillate

4. Air Surveillance

for tritium using liquid scintillation spectrometry. All analytical procedures meet the requirements of 40 Code of Federal Regulations (CFR) 61, Appendix B, Method 114. The AIRNET project plan provides a summary of the target minimum detectable activity (MDA) for the biweekly and quarterly samples.

d. Laboratory Quality Control Samples. For 2001, ESH-17 and the contractor analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical chemistry laboratories. The chemistry met the QA requirements for the AIRNET program. Section F, later in this chapter provides additional detail.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations.

Tables 4-1 through 4-12 summarize the ambient air concentrations calculated from the field and analytical data. Table 4-1 summarizes the average background concentrations of airborne radioactivity for the last five years. Tables 4-2 through 4-12 summarize ambient air concentrations by the type of radioactivity or by specific radionuclides. The summaries include the number of measurements; the number of these measurements less than the 2s uncertainty; the maximum, minimum, and average concentrations; the sample standard deviation; and, for the group summaries, the 95% confidence intervals. The number of measurements is normally equal to the number of samples analyzed. The number of measurements less than the uncertainty is the number of calculated net air concentrations that are less than their individual propagated net 2s analytical uncertainties. These concentrations are defined as not having measurable amounts of the material of interest. The MDAs in Tables 4-11 and 4-12 are the levels that the instrumentation could detect under ideal conditions.

All AIRNET concentrations and doses are total measurements without any type of regional background subtractions. However, beginning in 2000, the concentrations and uncertainties reported in Tables 4-2 through 4-10 are net concentrations and net uncertainties. The net air concentrations, or blank-corrected data, include corrections for the radioactivity from the filter material and the analytical process. The net concentrations are usually somewhat lower than the gross concentrations because small amounts of radioactivity are present in the filter material, the acids used to dissolve the filter, and the tracers added to

determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or minus (\pm) another value represent a 95% confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement and analytical errors but also seasonal and spatial variations as well. As such, the calculated 95% confidence intervals are overestimated (wider) for the average concentrations and probably represent confidence intervals that approach 100%. In addition, the air concentration standard deviations in the tables represent one standard deviation as calculated from the sample data. All ambient concentrations are activity concentrations per actual cubic meter of sampled air.

Some values in the tables indicate that we measured negative concentrations of radionuclides in the ambient air, which is physically impossible. However, it is possible for the measured concentration to be negative because the measured concentration is a sum of the true value and all random errors. As the true value approaches zero, the measured value approaches the total random errors, which can be negative or positive and overwhelm the true value. Arbitrarily discarding negative values when the true value is near zero will result in overestimated ambient concentrations.

b. Gross Alpha and Beta Radioactivity.

We use gross alpha and gross beta analyses primarily to evaluate general radiological air quality, to identify potential trends, and to detect sampling problems. If gross activity in a sample is consistent with past observations and background, immediate special analyses for specific radionuclides are not necessary. If the gross analytical results appear to be elevated, then immediate analyses for specific radionuclides may be performed to investigate a potential problem, such as an unplanned release. Gross alpha and beta activity in air exhibits considerable environmental variability and, for alpha measurements, analytical variability. These naturally occurring sources of variability generally overwhelm any Laboratory contributions.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air

to be 2 fCi per cubic meter. The primary alpha activity is due to polonium-210 (a decay product of radon) and other naturally occurring radionuclides (NCRP 1975, NCRP 1987). The NCRP also estimated national average concentration levels of long-lived gross beta activity in air to be 20 fCi per cubic meter. The presence of lead-210 and bismuth-210 (also decay products of radon) and other naturally occurring radionuclides is the primary cause of this activity.

In 2001, we collected and analyzed more than 1,000 air samples for gross alpha and gross beta activity. As shown in Table 4-2, the annual means for all of the stations are less than half of the NCRP's estimated average (2 fCi per cubic meter) for gross alpha concentrations. At least two factors contribute to these seemingly lower concentrations: the use of actual sampled air volumes instead of standard temperature and pressure (STP) volumes and the burial of alpha emitters in the filter that are not measured by front-face counting. Gross alpha activity is almost entirely from the decay of natural radionuclides, primarily polonium-210 in the radon-222 decay chain, and is dependent on variations in natural conditions such as atmospheric pressure, atmospheric mixing, temperature, soil moisture, and the "age" of the radon. Differences among the sampler groups may be attributable to these factors (NCRP 1975, NCRP 1987).

Table 4-3 shows gross beta concentrations within and around the Laboratory. These data show variability similar to the gross alpha concentrations. All of the annual averages are below 20 fCi per cubic meter, the NCRP-estimated national average for beta concentrations, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. In addition, we also calculate the gross beta measurements on the actual sampled air volumes instead of STP volumes. The primary source of measured gross beta activity in the particulate matter samples is the bismuth-210 in the radon-222 decay chain.

c. Tritium. Tritium is present in the environment primarily as the result of nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure the tritium as an oxide (HTO or T₂O) (water) because the dose impact is about 14,000 times higher than if it were hydrogen (DOE 1988b).

Estimating ambient levels of tritium as an oxide (water) requires two factors: water vapor concentrations in the air and tritium concentrations in the water vapor. Both of these need to be representative of the

true concentrations to obtain an accurate estimate of the ambient tritium concentrations. We found that the silica gel collection media were not capable of removing all of the moisture from the atmosphere (Eberhart 1999). Because 100% of the water was not collected on the silica gel and we used this water to measure water vapor concentrations, the atmospheric water vapor, and therefore tritiated water, has been underestimated. However, data from the meteorological monitoring network provide accurate measurements of atmospheric water vapor concentrations and have been combined with the analytical results to calculate all ambient tritium concentrations in this report. The EPA approved use of this method for compliance calculations of atmospheric tritium concentrations in March 1999 (EPA 1999).

When these experiments on silica gel collection efficiencies were being conducted, we also evaluated the dilution effect of the bound water in the silica gel. The effect of the bound water did not appear to cause any significant dilution of the tritium samples. However, more recent results, as described below, have indicated otherwise.

To better evaluate the performance of our analytical laboratory, we changed our tritium spike program at the beginning of 2001. Before 2001, we submitted 10-g water samples with known concentrations of tritium to the laboratory for analysis. Starting with the first sampling period in 2001, these spikes were evaporated and absorbed onto silica gel and then sent to the analytical lab for distillation and analysis. The average tritium concentration in the spikes, which are diluted National Institute of Standards and Technology (NIST) standards, for 1999 through 2000 was 96% of the NIST-traceable concentrations. For 2001, the average tritium concentrations in the spikes recovered from the silica gel dropped to 61%. We explored a variety of possible causes, but the apparent causes were loss of tritium to the bound water in the silica gel and the vapor pressure isotopic effect (Rossen et al., 2000). A method to correct for the bound water and the isotopic effect has been published (Rossen et al., 2000). Silica gel samples are weighed after drying, denatured at temperatures from 800 to 1000°C, and then weighed again to determine the bound water in the dried silica gel. The percent bound water, which was determined to be 3.6% of the dried silica gel mass, and the isotopic effect correction (a factor of 1.03) have been applied to all tritium data in Tables 4-1 and 4-4.

4. Air Surveillance

Table 4-4 presents the sampling results for tritiated water concentrations. The annual concentrations for 2001 at all of the regional and pueblo stations were lower than all of the on-site and perimeter stations except for the San Ildefonso Pueblo station (41), which had slightly higher concentrations than the Western Arizona Street station (80). In addition, most of the on-site stations in technical areas with tritium sources (TA-16, TA-21, and TA-54) had higher annual concentrations than the perimeter stations. These data indicate that the Laboratory is a measurable source of tritium based on ambient concentrations. All annual mean concentrations at all sampling sites were well below the applicable EPA and DOE guidelines.

Another way to view the data is by comparing the number of biweekly concentrations greater than their 2s uncertainty (that is, quantitatively measurable) with the total number of measurements. Less than 2% of the measurements at regional and pueblo locations are above their 2s uncertainties, whereas about 38% of the measurements at the perimeter locations are higher. Finally, more than 98% of the measurements in technical areas with tritium sources are higher than their uncertainties.

The highest off-site annual concentration, 13.8 pCi/m^3 , was at station 08 (near the McDonald's restaurant), which is close to TA-41. This concentration is equivalent to about 1% of the EPA public dose limit. We measured elevated concentrations at a number of on-site stations, with the highest annual concentration at station 35 within TA-54, Area G. This sampler is located in a radiological control area, near shafts containing tritium-contaminated waste. This annual mean concentration, 1826 pCi/m^3 , is only 0.01% of the DOE DAC for worker exposure.

d. Plutonium. While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), it is not naturally present in measurable quantities in the ambient air. All measurable sources are from plutonium research and development activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air. Four isotopes of concern can be present in the atmosphere: plutonium-238, plutonium-239, plutonium-240, and plutonium-241.

Plutonium-241 is not measured because it is a low-energy beta emitter that decays to americium-241, which we do measure. This beta decay is not only hard to measure, but the dose is small when compared with americium-241. Plutonium-239 and plutonium-240 are indistinguishable by alpha spectroscopy and are grouped together for analytical purposes. Therefore, any ambient air concentrations or analyses listed as plutonium-239 actually represent both plutonium-239 and plutonium-240.

Table 4-5 presents sampling results for plutonium-238. No off-site quarterly concentrations were above their uncertainty levels. Three on-site quarterly concentrations were above their uncertainties, with all three at TA-54, Area G. Two of the measurements were at station 34, which indicates that the concentrations at this location are quantitative and above background levels. The annual mean activity at this location was 3.2 aCi/m^3 , which corresponds to 0.0001% of the DOE DAC for worker exposure. This same location also had the highest 1999 and 2000 annual concentrations.

Sampling results for plutonium-239, -240 appear in Table 4-6. As with the plutonium-238 analyses, most of the analytical results were below their estimated uncertainties. Five off-site locations (08, 09, 13, 32, and 66), all in Los Alamos County, had one or more quarters with measurable concentrations of plutonium-239, -240. The highest off-site annual mean was at station 66 (Los Alamos Inn-South), with a concentration of 20 aCi/m^3 or about 1% of the EPA public dose limit. These higher ambient concentrations are apparently from historical TA-1 activities that deposited small amount of plutonium on the hillside below station 66. We recorded the highest annual on-site concentration for plutonium-239, -240 at station 34 in Area G. The concentration was 25 aCi/m^3 , which is about 0.001% of the DOE DAC for workplace exposure.

e. Americium-241. Americium-241, a decay product of plutonium-241, is the primary source of radiation from this plutonium isotope. Nuclear explosions, the nuclear fuel cycle, and other processing of plutonium release plutonium-241 to the environment.

Table 4-7 presents the americium results. As with the plutonium isotopes, americium is present in very low concentrations in the environment. No quarterly off-site measurements were above their uncertainty levels.

The only location with measurements above the uncertainties was Area G where 10 of 32 quarterly samples were above their 2s uncertainties; these results were similar to 2000 when 12 were above their uncertainties. The overall concentration at Area G was more than 10 times higher than for any group of samplers, with an average of 10 aCi/m^3 . The highest annual on-site concentration was 67 aCi/m^3 at station 34 in Area G. This concentration is about 0.003% of the DOE DAC for worker exposure.

f. Uranium. Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. The natural sources of uranium are crustal rocks and soils. Therefore, the ambient concentrations depend upon the mass of suspended particulate matter, the uranium concentrations in the parent material, and any local sources. Typical uranium crustal concentrations range from 0.5 ppm to 5 ppm, but local concentrations can be well above this range (Eisenbud and Gesell 1997). Relative isotopic abundances are constant and well characterized. Uranium-238 and uranium-234 are essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (as calculated from Walker et al., 1989). Thus, activity concentrations of these two isotopes are effectively the same in particulate matter derived from natural sources. Because known LANL uranium emissions are enriched (excess uranium-234 and -235) or depleted (excess uranium-238), we can use comparisons of isotopic concentrations to estimate LANL contributions. Using excess uranium-234 to detect the presence of enriched uranium may not seem suitable because the enrichment process is usually designed to increase uranium-235 concentrations. However, the enrichment process normally increases uranium-234 at a faster rate than uranium-235, and the dose from natural uranium is about an order of magnitude higher for uranium-234 than for uranium-235. Tables 4-8 through 4-10 give uranium results by isotope. Figure 4-4 shows the plotted annual uranium-234 and -238 concentrations along with a line representing the natural abundance of the two isotopes. In addition, the figure identifies several samplers by their site number and/or by the presence or absence of a sample with depleted uranium.

All annual mean concentrations of the three uranium isotopes were well below the applicable EPA and DOE guidelines. The maximum annual uranium concentrations were at locations with high dust levels

from local soil disturbances such as dirt roads at the Los Alamos County Landfill and Area G. The maximum annual off-site uranium-234 concentration was 51 aCi/m^3 at the landfill (station 32), which is less than 0.1% of the EPA public exposure limit. One on-site location, station 77 in a controlled access area known to have depleted uranium, had the highest annual uranium-238 concentration of 125 aCi/m^3 . This concentration is about 0.0006% of the DOE DAC for worker exposure. See Section A.7 of this chapter for additional information on station 77. The maximum annual off-site uranium-238 concentration was 54 aCi/m^3 , which was also at the landfill. As with the uranium-234 concentration, the uranium-238 concentration was less than 0.1% of the EPA limit. Most of the uranium-235 measurements (91%), both on- and off-site, were below the uncertainties, whereas about 5% of the uranium-234 and uranium-238 concentrations were below their 2s uncertainties. Consequently, most uranium-235 data should not be considered quantitative measurements and will not be evaluated as such because the other uranium isotopes, as described earlier in this section, are better indicators of Laboratory impact.

Both the regional and pueblo groupings had higher average concentrations of uranium-234 and uranium-238 than the perimeter group. The higher concentrations for the regional and pueblo groups result from increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, and other soil disturbances such as construction activities and even grazing but not any known “man-made” sources of uranium. Dry weather or a drier climate can also increase ambient concentrations of particulate matter and therefore uranium.

Fifteen sites (09, 14, 17, 20, 23, 30, 35, 47, 49, 51, 62, 71, 76, 77, and 78) had at least one quarter with excess uranium-238 as shown in Figure 4-4. We measured no excess uranium-234 during 2001. We identified these excess uranium concentrations by statistically comparing the uranium-234 and uranium-238 concentrations. If the concentrations in a sample were more than three standard deviations apart, the sample was considered to have excess isotopic uranium. It should be noted that the highest uranium concentrations, with the exception of station 77 which is in a controlled access area, were all attributable to natural uranium because these sites did not show any excess uranium-234 or uranium-238. See Section A.6 for additional detail on excess uranium isotopic measurements.

4. Air Surveillance

g. Gamma Spectroscopy Measurements. In 2001, gamma spectroscopy measurements were made on groups of filters including analyses of “clumps” (biweekly filters grouped across sites for a single sampling period) and quarterly composites (biweekly filters grouped across time for a single site). Even though these gamma emitters have no action levels *per se*, we would investigate any measurement, other than beryllium-7, potassium-40, and lead-210, above the MDA because the existing data indicate that such a measurement is highly unlikely except after an accidental release. Instead of action levels, the AIRNET Sampling and Analysis Plan (ESH-17 2000) lists the minimum detection levels for 16 gamma emitters that could either be released from Laboratory operations or that occur naturally in measurable amounts (beryllium-7 and lead-210). The minimum levels are equivalent to a dose of 0.5 mrem. The beryllium-7 and lead-210 measurements were the only isotopes above their MDAs.

Table 4-11 summarizes the “less than” concentrations. The average annual MDA for every radionuclide in this table meets the required minimum detection levels. Because every value used to calculate the average annual MDA was a “less than” value for the 14 radionuclides listed in the table, it is likely that the actual concentrations are 3 or more standard deviations away from the average MDA. As such, the ambient concentrations, which were calculated from the MDA values, are expressed as “much less” (\ll) values.

Table 4-12 summarizes the beryllium-7 and lead-210 data. Both beryllium-7 and lead-210 occur naturally in the atmosphere. Beryllium-7 is cosmogenically produced, whereas lead-210 is a decay product of radon-222. Some lead-210 is related to suspension of terrestrial particulate matter, but the primary source is atmospheric decay of radon-222 as shown in Figure 4-5. Even though the beryllium-7 and lead-210 are derived from gases, both become elements that are present as solids or particulate matter. These radionuclides will quickly coalesce into fine particles and also deposit on the surfaces of other suspended particles. The effective source is cosmic for beryllium-7 and terrestrial for lead-210, so the ratio of the two concentrations will vary, but they should be relatively constant for a given sampling period. Because all of the other radionuclides measured by gamma spectroscopy are “less than” values, measurements of these two radionuclides provide verification that the sample analysis process is working properly.

5. Investigation of Elevated Air Concentrations

Upon receiving the analytical chemistry data for biweekly and quarterly data, ESH-17 personnel calculated air concentrations and reviewed them to determine if any values indicated an unplanned release. Two action levels have been established: investigation and alert. Investigation levels are based on historical measurements and are designed to indicate that an air concentration is higher than expected. Alert levels are based on dose and require a more thorough, immediate follow-up.

In 2001, a number of air sampling values exceeded investigation levels. When a measured air concentration exceeds an investigation level, ESH-17 verifies that the calculations were done correctly and that the sampled air concentrations are likely to be representative, i.e., that no cross contamination has taken place. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations.

A number of uranium measurements exceeded action levels during 2001. In most cases, the follow-up investigation demonstrated that natural uranium associated with higher levels of suspended particulate matter produced the elevated uranium concentrations; the exceptions were for the depleted uranium concentrations discussed in Sections A.4.f of this chapter. Even though a number of sites had excess uranium-238, all concentrations, with the exception of station 77, were less than the maximum natural uranium concentration (the landfill station 32) and much less than the highest natural concentration during the past five years. Therefore, these concentrations *per se* do not raise any public health concerns beyond that posed by natural uranium.

In the AIRNET tritium discussion (A.4.c), the corrections for bound water in the silica gel and for isotopic effects were described. We have applied these corrections to the tritium data in this section. The following sections identify ten investigations that are not covered elsewhere in this document and that warrant further discussion.

Elevated Tritium near TA-41 (May, 2001)

During the first week of May 2001, a planned release of about 12 curies of tritiated water from D&D activities at TA-41 took place. Typically, TA-41 tritiated water (HTO) emissions are less than 10% this

amount. Several nearby AIRNET stations (08, 60, and 66) recorded ambient air concentrations of tritium above investigation levels with a maximum concentration of 22 pCi/m³. If these concentrations were an annual average, they would be less than 2% of the EPA dose limit, which is 1500 pCi/m³. As two-week averages, they represent about 1/26 of 2% of the EPA public dose limit.

2001 Americium and Plutonium Data at Area G

Americium-241 and plutonium-239 exceeded action levels at station 34 for all four quarters of 2001. In addition, one quarterly sample at this site exceeded its plutonium-238 investigate concentration. The concentrations of all three radionuclides at this site have been higher since early 1999. High concentrations for more than two years and the absence of similar increases at other locations in the eastern part of Area G indicate that these “investigate” concentrations remain localized and are caused by nearby waste-handling activities. These concentrations are less than 0.01% of the DOE workplace exposure standards.

During the fourth quarter of 2001, the plutonium-239 concentration at station 50 was 23 aCi/m³. This sampler is located in Area G, but the analytical results over the last several years have been on the order of 0–5 aCi/m³. It is not yet known what caused this increase. This concentration is about 0.001% of the DOE workplace exposure standards.

Sites near TA-41 with Tritium Investigations for July 2, 2001 (010702 sampling period)

The tritium concentrations for four stations (8, 60, 66, and possibly 62) exceeded their Investigation Action Levels (IAL) and correlate very closely in time and location to planned tritiated water emissions at TA-41 of about 25 curies from June 19 through July 3, 2001. Typically, TA-41 HTO emissions are less than 10% this amount. If the maximum concentration (44 pCi/m³) were an annual average, it would be equivalent to about 3% of the EPA dose limit which is 1500 pCi/m³. As a two-week average, it represents about 1/26 of 3% of the EPA public dose limit.

Sites near TA-21 with Tritium Investigations for July 2, 2001 (010702 sampling period)

The tritium concentrations for stations 9, 20, 62, and 71 exceeded their IAL and correlate very closely

in time and location to planned HTO emissions at TA-21-209 of about 21 curies from June 19 through July 3, 2001. Typically, TA-21 HTO emissions are smaller than this amount. If the maximum concentration (19 pCi/m³) were an annual average, it would be equivalent to about 1% of the EPA dose limit which is 1500 pCi/m³. As a two-week average, it represents about 1/26 of 1% of the EPA public dose limit.

Sites near TA-16 with Tritium Investigations for July 16, 2001

Two adjacent sample sites near TA-16 exceeded their IAL. The higher measured emissions at these locations may be due to increased emissions from the Weapons Engineering Tritium Facility (WETF) at TA-16. The concentrations correlate closely in time and location with routine calibration exercises at TA-16. If the highest concentration (8 pCi/m³) were an annual average, it would be equivalent to less than 1% of the EPA dose limit, which corresponds to 1500 pCi/m³.

Sites near TA-21 with Tritium Investigations for July 16 and July 30, 2001

One sample site at TA-21, station 20, exceeded its IAL over two consecutive sampling periods. The concentrations correlate closely in time and location to HTO emissions at TA-21-209 of about 46 curies during July 2001. If the highest concentration (19 pCi/m³) were an annual average, it would be equivalent to approximately 1% of the EPA dose limit, which corresponds to 1500 pCi/m³.

Sites near TA-33 with Tritium Investigations for August 2001

Two sample sites near TA-33 exceeded their IAL for the August 27 sampling period. The concentrations correlate closely in time and location to planned HTO emissions at TA-33 of about 33 curies from August 14 through 28, 2001. If the highest concentration (12 pCi/m³) were an annual average, it would be equivalent to less than 1% of the EPA dose limit, which corresponds to 1500 pCi/m³.

Sites near TA-41 with Tritium Investigations for July 16, 2001; July 30, 2001; August 13, 2001; and August 27, 2001

Five sample sites near TA-41 (8, 12, 60, 61, and 66) exceeded their IAL over four consecutive sam-

4. Air Surveillance

pling periods. The concentrations for stations 8, 12, 60, 61, and 66 correlate closely in time and location to planned HTO emissions at TA-41 of about 24 curies from July 3 through 31, 2001. Additional HTO emissions of about 12 curies were released from July 31 through August 28, 2001. If the highest concentration of these 20 measurements (60 pCi/m^3) were an annual average, it would be equivalent to 4% of the EPA public dose limit, which corresponds to 1500 pCi/m^3 .

Tritium Investigations at Area G during 2001

Each year, as the ambient temperature increases, the tritium concentrations at TA-54 increase because of the diffusion of the tritium from the stored waste. Because this effect is a known, repeated phenomenon, we use a moving average to determine if unexpected results are being measured. At station 35, which is located next to tritium waste disposal shafts, this temperature effect is accentuated. During sample periods ending July 30, August 27, and September 24, airborne tritium levels at this site exceeded the moving-average action levels. The maximum two-week concentration at station 35 was 7316 pCi/m^3 . These investigate concentrations peaked at approximately twice the highest values previously recorded in other years. An investigation identified no specific explanation for these new peaks. Weather conditions, a “wave” of tritium diffusion through the soil, or physical changes in the buried waste containers may have caused this increase. As noted previously, the annual mean concentration at this site, 1826 pCi/m^3 , is only 0.01% of the DOE DAC for worker exposure, which is $20,000,000 \text{ pCi/m}^3$.

TA-21 Plutonium-239 Fourth Quarter Investigation

Station 71 at TA-21 had plutonium-239 results significantly above its IAL with a concentration of 26 aCi/m^3 . The increased result may be due to resuspension of historical soil contamination or disconnecting and cleaning up some of the systems within building 344 in preparation for D&D activity. The concentration is about 0.001% of the DOE DAC for worker exposure standard of $2,000,000 \text{ aCi/m}^3$.

6. Long-Term Trends

Previous Environmental Surveillance Reports covered long-term trends for tritium (ESP 1998 and ESP

1999); gross alpha, gross beta, and gamma measurements (ESP 2000); and plutonium and americium (ESP 2001). This year, we evaluated trends for uranium. The Laboratory has measured isotopic uranium concentrations in quarterly particulate matter composites since the first quarter of 1995. As previously described, this analytical change has allowed us to identify and quantify LANL’s impact on ambient concentrations of uranium, which are either enriched uranium (excess uranium-234 and -235) or depleted uranium (excess uranium-238). These data are shown in Figures 4-6, 4-7, and 4-8. Two of these figures include uranium-235 concentrations, but it should be noted that most of the measurements are less than their analytical uncertainty because the analytical process measures activity, which is low for uranium-235.

Figure 4-6 compares the network-wide uranium isotopic concentrations by quarter. Even though the annual and quarterly concentrations vary, peak concentrations for all three isotopes occur during the second quarter of each year. Furthermore, the uranium-238 concentrations have been slightly, but consistently, higher than the uranium-234 concentrations since the first quarter of 1998 indicating the presence of depleted uranium in some samples. Station 77 was not included in these averages because of the persistent and known presence of depleted uranium in the samples as discussed below.

Station 77 at TA-36 is located in a posted radiation control area where depleted uranium is still present as surface contamination from explosive tests. It has been previously identified as a location with measured excess ambient concentrations of uranium-238 (Eberhart et al., 1999; ESP 1999; ESP 2000; and ESP 2001). Of the 24 quarterly composites analyzed for isotopic uranium at this site, 20 have had excess uranium-238. The 2001 uranium-238 and uranium-234 concentrations at this site were 125 and 24 aCi/m^3 respectively. These concentrations were higher than the last several years but comparable to the 1995 concentrations of 131 and 20 aCi/m^3 . If we assume that about 15% of the activity in depleted uranium is uranium-234, the calculated LANL contributions at this location were about 22 aCi/m^3 of uranium-234 and 123 aCi/m^3 of uranium-238. Therefore, the combined estimated LANL contribution at this on-site controlled access location is about 0.0007% of the DOE DAC for workplace exposure.

Figure 4-7 shows the number of individual sites with quarterly concentrations of measured excess

isotopic uranium. As shown in this figure, depleted uranium, as indicated by excess uranium-238, has usually been detected in at least one sample per quarter—most notably the first quarters of 1997 and 2001 when significant differences (3s) were detected in about 25% of the samples. All of the samples with depleted uranium were collected on LANL property or within Los Alamos County. In the six years before 2001, we collected only 15 quarterly composite samples with excess uranium-238 off-site. During 2001, seven off-site samples with excess uranium-238 were collected. In addition, the number of quarterly composites with depleted uranium was higher in 2001 than any of the years since isotopic measurements started in 1995. We are investigating these increases in depleted uranium, but it is believed that the loss in ground cover and vegetation from the Cerro Grande fire combined with the below-average precipitation for the last several years may have increased resuspension of depleted uranium.

Only a few samples show excess enriched uranium, and most of these occurred in 1996. There is some evidence to indicate that these samples were contaminated in a laboratory, but this contamination has not been proven, and the concentrations are still considered valid environmental measurements.

B. Stack Sampling for Radionuclides

1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Air Quality personnel at the Laboratory evaluate these operations to determine impacts on the public and the environment. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving as much as 0.1 mrem in a year, the Laboratory must sample the stack in accordance with Title 40 Code of Federal Regulations (CFR) 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities” (EPA 1989). As of the end of 2001, we identified 28 stacks as meeting this criterion. Two additional sampling systems were in place to meet DOE requirements for nuclear facilities prescribed in their respective technical or operational safety requirements. Where sampling is not required, emissions are

estimated using engineering calculations and radionuclide materials usage information.

2. Sampling Methodology

As of the end of 2001, LANL continuously sampled 30 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products (VAP), (3) tritium, and (4) gaseous/mixed air activation products (G/MAP). For each of these emission types, the Laboratory employs an appropriate sampling method, as described below.

Emissions of radioactive particulate matter generated by operations at facilities such as the Chemistry and Metallurgy Research Building (CMR) and TA-55 are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through the filter that captures small particles of radioactive material. These samples are analyzed weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, ESH-17 composites these samples to be shipped to an off-site commercial laboratory. The commercial laboratory analyzes these composited samples to determine the total activity of materials such as uranium-234, -235, and -238; plutonium-238 and -239, -240; and americium-241. These data are then used to calculate emissions.

A charcoal cartridge samples VAP emissions such as selenium-75 and bromine-77 generated by LANSCE operations and by hot cell activities at CMR and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. We determine the amount and identity of the radionuclide(s) present on the filter with gamma spectroscopy.

We use a collection device known as a bubbler to measure tritium emissions from the Laboratory's tritium facilities. This device enables the Laboratory to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler operates by pulling a continuous sample of air from the stack, which is then “bubbled” through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). After “bubbling” through these three vials, essentially all HTO is

4. Air Surveillance

removed from the air, leaving only elemental tritium. The sample containing the elemental tritium is then passed through a palladium catalyst that converts the elemental tritium to HTO. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. The amount of HTO and HT is determined by analyzing the ethylene glycol for the presence of tritium using liquid scintillation counting (LSC).

Although the tritium bubbler described above is the Laboratory's preferred method for measuring tritium emissions, we employ a silica gel sampler at the LANSCE facility. A sample of stack air is pulled through a cartridge containing silica gel. The silica gel collects the water vapor from the air, including any HTO. The water is distilled from the sample, and the amount of HTO is determined by analyzing the water using LSC. Using silica gel is necessary because the ethylene glycol will also collect some of the gaseous emissions from LANSCE other than tritium. These additional radionuclides will interfere with the determination of tritium, resulting in less than desirable results. Also, because the primary source for tritium is activated water, sampling for only HTO is appropriate. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions.

We measure G/MAP emissions resulting from activities at LANSCE using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample. We use gamma spectroscopy and decay curves to identify specific radioisotopes.

3. Sampling Procedures and Data Analysis

Sampling and Analysis. We chose analytical methods to comply with EPA requirements (40 CFR 61, Appendix B, Method 114). See Section F in this chapter for the results of analytical quality assurance measurements. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

Particulate Matter Emissions. We generally removed and replaced the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions weekly and transported them to the Health Physics Analysis Laboratory

(HPAL). Before screening the samples for the presence of alpha and beta activity, the HPAL allowed approximately 72 hours for the short-lived progeny of radon to decay. These initial screening analyses ensure that potential emissions were within normal values. The HPAL performed final analyses after the sample had been allowed to decay for approximately one week. In addition to alpha and beta analyses, the HPAL used gamma spectroscopy to identify the energies of gamma ray emissions from the samples. Because the energy of decay is specific to a given radioactive isotope, the HPAL could determine the identity of any isotopes detected by the gamma spectroscopy. The amount, or activity, of an isotope could then be found by noting the number of photons detected during analysis. LANSCE glass-fiber filters were analyzed using only gamma spectroscopy.

Because gross alpha/beta counting cannot identify specific radionuclides, the glass-fiber filters were composited every six months for radiochemical analysis at an off-site commercial laboratory. We used the data from these composite analyses to quantify emissions of radionuclides such as the isotopes of uranium and plutonium. To ensure that the analyses requested (e.g., uranium-234, -235, and -238 and plutonium-238 and -239, -240, etc.) identified all significant activity in the composites, ESH-17 compared the results of the isotopic analysis to gross activity measurements.

VAP Emissions. We generally removed and replaced the charcoal canisters that sample facilities with the potential for significant VAP emissions weekly. These samples were transported to the HPAL where gamma spectroscopy, as described above, identified and quantified the presence of vaporous radioactive isotopes.

Tritium Emissions. Tritium bubbler samples used to sample facilities with the potential for significant elemental and oxide tritium emissions were generally collected and transported to the HPAL on a weekly basis. The HPAL added an aliquot of each sample to a liquid scintillation cocktail and determined the amount of tritium in each vial by LSC.

Silica gel samples were used to sample facilities with the potential for significant tritium emissions in the oxide form only, where the bubbler system would not be appropriate. These samples were transported to the Analytical Chemistry Sciences Group (C-ACS), where C-ACS staff distilled the water from the silica gel and determined the amount of tritium in the sample using LSC.

G/MAP Emissions. We used continuous monitoring, rather than off-line sampling, to record and report G/MAP emissions for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed offline. The G/MAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total G/MAP emissions were measured with the ionization chamber. The real-time current measured by this ionization chamber was recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle was integrated on a daily basis. The composition of these G/MAP emissions was analyzed with the gamma spectroscopy system. Using decay curves and energy spectra to identify the various radionuclides, Air Quality personnel determined the relative composition of the emissions. Decay curves were typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

4. Analytical Results

Measurements of Laboratory stack emissions during 2001 totaled approximately 15,400 Ci. Of this total, tritium emissions composed approximately 9400 Ci, and air activation products from LANSCE stacks contributed nearly 6000 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and particulate/vapor activation products were less than 1 Ci.

Table 4-13 provides detailed emissions data for Laboratory buildings with sampled stacks. Table 4-14 provides a detailed listing of the constituent radionuclides in the groupings of G/MAP and particulate/vapor activation products (P/VAP). Table 4-15 presents the half-lives of the radionuclides emitted by the Laboratory. During 2001, nonpoint source emissions of activated air from the LANSCE facility (TA-53) comprised approximately 150 Ci carbon-11 and 6 Ci argon-41, whereas TA-18 contributed 0.29 Ci argon-41.

5. Long-Term Trends

Figures 4-9 through 4-12 present radioactive emissions from sampled Laboratory stacks. These

figures illustrate trends in measured emissions for plutonium, uranium, tritium, and G/MAP emissions, respectively. As the figures demonstrate, tritium emissions and G/MAP emissions each showed a significant increase for 2001. Emissions from plutonium and uranium isotopes stayed relatively steady since 2000.

Emissions from tritium handling facilities increased in 2001 over previous years. A January 31, 2001, release of 7600 curies of tritium gas (HT) from WETF, TA-16-205, dominated these tritium emissions. This single release constitutes over 80% of the total Laboratory tritium emissions for 2001. The release occurred when a container of legacy waste failed during processing. The container was originally thought to contain less than 50 curies of tritium. Failure of the container released the high-purity tritium gas into the stack ventilation system. The off-site dose from this release was well below any regulatory thresholds. See <http://drambuie.lanl.gov/~esh7/Finals/tritfacils/0201.html> for a complete description of the event.

Emissions from other facilities, notably TA-33-86, TA-21-209, and TA-41-4, increased because of cleanup operations in preparation for the D&D of these areas. TA-33-86, which originally housed the High Pressure Tritium Laboratory (HPTL), has been shut down for several years. TA-41-4 likewise has ceased operations, and personnel are preparing the facility for D&D. In these facilities, we expect increased emissions from activities such as equipment disassembly and opening pipes and containers to demonstrate that all significant tritium has been removed. TA-21-209 is transferring its tritium operations to WETF, and the building is being prepared for D&D. As tritium-contaminated systems are dismantled and prepared for removal and disposal, increased releases of tritium are expected. However, overall long-term emissions from all these facilities will decrease following such D&D preparation. As mentioned, all releases in 2001 were well below regulatory limits.

In 2001, LANSCE operated in the same configuration as 2000, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center causing the majority of radioactive air emissions. However, changes to the 1L Target cooling water system operation resulted in more off-gassing of very short-lived radionuclides (primarily oxygen-15) from the water systems into the stack air stream. As a result, total emissions from the TA-53-7 stack increased in 2001, while still remaining well below any regulatory limits.

4. Air Surveillance

Figure 4-13 shows the individual contribution of each of these emission types to the total Laboratory emissions. It clearly shows that G/MAP emissions and tritium emissions make up the vast majority of radioactive stack emissions.

C. Gamma and Neutron Radiation Monitoring Program (*Mike McNaughton*)

1. Introduction

ESH-17 monitors gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000).

This radiation consists of both naturally occurring and man-made radiation. Naturally occurring radiation originates from terrestrial and cosmic sources. Because the natural radiation doses are generally much larger than those from man-made sources, it is extremely difficult to distinguish man-made sources from the natural background.

Naturally occurring terrestrial radiation varies seasonally and geographically. Seasonally, radiation levels can vary up to 25% at a given location because of changes in soil moisture and snow cover that reduce or block the radiation from terrestrial sources (NCRP 1975). Spatial variation results from both the soil type and the geometry; for example, dosimeters that are placed in a canyon will receive radiation from the side walls of the canyon as well as from the canyon bottom and will record higher radiation exposures than those dosimeters on a mesa top that do not receive exposure from the walls. The aerial surveys of Los Alamos (EG&G 1989, EG&G 1990, DOE/NV 1998, and DOE/NV 1999) show variations of a factor of three in terrestrial radiation. Measurements of soil concentrations support these surveys: according to Longmire et al., 1996, thorium and uranium concentrations on the Pajarito Plateau range from 0.7 to 3 pCi/g, and potassium-40 ranges from 12 to 30 pCi/g; these concentrations result in terrestrial radiation from 50 to 150 mrem/yr, with the higher values generally being in the canyons.

Naturally occurring ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding (NCRP 1975). At sea level, the dose rate from cosmic sources is 27 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km, receives 70 mrem/yr from cosmic sources, whereas

White Rock, at an elevation of 1.9 km, receives 60 mrem/yr, and Española, at 1.7 km, receives 50 mrem/yr.

In summary, the dose rate from natural terrestrial and cosmic sources varies from about 100 to 200 mrem/yr. In publicly accessible locations, the dose rate from man-made radiation is much smaller than, and difficult to distinguish from, natural radiation.

2. Monitoring Network

a. Dosimeter Locations. In an attempt to distinguish any impact from Laboratory operations, ESH-17 has located 140 thermoluminescent dosimeter (TLD) stations around the Laboratory and in the surrounding communities. Beginning in January 2000, the monitoring locations were selected according to the criteria in McNaughton et al., 2000. See Figure 4-14 for the present locations of TLDs.

b. Albedo Dosimeters. We monitor potential neutron doses with twelve albedo TLD stations. We maintain these stations around TA-18 and Building 130 of TA-3. Albedo dosimeters are sensitive to neutrons and use a hydrogenous material to simulate the human body, which causes neutron backscatter.

Background stations are located at Santa Fe and TA-49, and a control dosimeter is kept in a shielded vault.

3. Quality Assurance

ESH-17's operating procedures (ESH-17 2002) contain procedures that outline the QA/QC (quality assurance/quality control) protocols; placement and retrieval of the dosimeters; reading of the dosimeters; and data handling, validation, and tabulation. The Health Physics Measurements Group (ESH-4) calibration lab calibrates the dosimeters.

We estimated the uncertainty in the TLD data by combining the uncertainties from three sources. The standard deviation of the individual TLD chips was calculated from the spread in sets of 5 chips exposed to the same dose and was 3%. We calculated the uncertainty in the light-output-to-dose calibration from the variation of the individual calibrations; it was 5%. The uncertainty in the fade correction was calculated from 20 sets of fade dosimeters with each set each exposed to the same conditions and was 4%. Combining these in the standard way, the overall one-standard-deviation uncertainty is 7%.

As an independent check of the accuracy of our dosimeters, we submitted 14 dosimeters to the 12th International Intercomparison of Environmental Dosimeters organized by the DOE's Environmental Measurements Lab (EML) (<http://www.eml.doe.gov/iied/>). According to the preliminary results, the average dose our field dosimeters measured was 168 mrem, which is 4% higher than the EML measurement of 161 mrem. This result is within the expected margin of uncertainty and is therefore satisfactory.

The DOE Laboratory Accreditation Program has accredited the albedo dosimeters that ESH-4 provides. ESH-4 provides quality assurance for the albedo dosimeters.

4. Analytical Results

a. Gamma TLD Dosimeters. Table 4-16 presents the results for the gamma TLD dosimeters. For some stations, one or more quarters of data are not available as a result of dosimeter loss. We have replaced the missing data by the average of the other quarters.

The annual dose equivalents at almost all stations ranged from 100 to 200 mrem. These dose rates are consistent with natural background radiation and with previous measurements. The largest natural-background dose rates are in low-lying areas and canyons (e.g., at stations 20, 37, 59, 69, and 70) where terrestrial background is high (DOE/NV/11718-107) and canyon walls contribute additional dose. None of these measurements indicates a contribution from Laboratory operations.

The stations with a measurable contribution from Laboratory operations are at TA-18 (station 28), TA-53 (stations 64, 104, and 114–116), TA-3-130 (stations 117–119), and TA-21 (station 323).

At TA-18, most of the external radiation dose is from neutrons, which are measured by the albedo dosimeters discussed in Section 4.c, below. The gamma dose at station 28 is smaller than the uncertainty in the measurement. Though the gamma dose at station 18 is larger than average, this reading is mostly a result of terrestrial radiation in the canyon.

Stations 104 and 114–116 are close to the TA-53 lagoons where activated material such as cobalt-60 has accumulated. Station 64 is close to the TA-53 “boneyard” where radioactive materials are stored. Access to TA-53 is restricted.

Stations 117–119 are close to the TA-3-130 calibration laboratory; they are 27 m north, 10 m east, and 8

m south, respectively. After subtracting approximately 120 mrem of natural background radiation, the dose measurements are consistent with the distances.

Stations 118 and 119 are within a fenced area and not accessible to the public. Station 117 is on the fence along the south side of Pajarito Road.

The potential dose to an individual on Pajarito Road is the sum of the gamma dose discussed in this section and the neutron dose discussed in Section 4.c, below. The doses that appear in the tables include natural background and would only apply if an individual remained close to the dosimeter 24 hours a day and 365 days per year.

Station 323 at TA-21, MDA T, is contaminated with 50 pCi/g of cesium-137 (LANL 1991, pp. 16–124). The calculated dose rate from this contamination is 200 mrem/yr. Considering that the dosimeter is on the boundary fence of Area T, the calculation is in reasonable agreement with the measurement, which is about 100 mrem/yr above background. Area T is not accessible to the public.

b. TA-54, Area G. Table 4-17 presents the results from monitoring the TA-54, Area G, waste site. Figure 4-2 shows the locations of the dosimeters at TA-54. As in previous years, the highest dose rates are near building 375 (stations 605–6 to the north), buildings 229-232 (stations 611–4 to the southeast), and building 49 (stations 623–4 to the southwest). The dose rates are the result of radioactive waste stored in these buildings. The increased dose rate from building 375 led us to locate new dosimeter stations 642 and 643 on the fence at the boundary between DOE and San Ildefonso Pueblo land. Although the gamma dose rates at these stations are at the upper end of the range of natural background radiation, we believe this rate is a result of high levels of terrestrial radiation in the canyon and from the canyon walls. Two items of evidence support this conclusion: calculations show the dose from building 375 at the DOE boundary is too small to measure, and the NEWNET station “LANL Buey East,” which is close to stations 642 and 643, does not show an increased dose rate. NEWNET is discussed in Section H.

c. Albedo Dosimeters. Table 4-18 presents the monitoring results from the TA-18 albedo dosimeters. The values in Table 4-18 would apply to a hypothetical individual who remains continuously at the specified location.

The neutron dose that a dosimeter measures depends on the neutron-energy spectrum. We calculate

4. Air Surveillance

the actual neutron dose by multiplying the dosimeter reading by the neutron correction factor, NCF. We calculated the dose from TA-18 using the NCF = 0.145, which corresponds to the neutron energy spectrum from the DOE-standard D₂O-moderated neutron spectrum from californium-252. The reference McNaughton (2000) discusses the reasons for this choice.

Albedo-dosimeter location 10 is collocated with gamma-dosimeter station 117, on the fence south of Pajarito Road and 27 m north of the TA-3-130 calibration sources. The total dose at this location is the sum of the gamma and the neutron dose equivalents.

D. Nonradioactive Ambient Air Monitoring (*Ernie Gladney and Jean Dewart*)

1. Introduction

During the spring of 2000, the Cerro Grande fire reached LANL and ignited both aboveground vegetation and disposed materials in several landfills. The fire raised concerns about the potential human health impacts from chemicals emitted by the combustion of these Laboratory materials, and short-term, intensive air monitoring studies were performed at that time. Unlike the radiological data from many years of AIRNET sampling, LANL did not have an adequate database of nonradiological species under baseline conditions with which to compare data collected during the fire. During 2001, ESH-17 designed and implemented a new air-monitoring program, entitled NonRadNet, to provide these types of data under normal conditions. The objectives of NonRadNet are to

- develop the capability for collecting nonradiological air monitoring data,
- conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest the Laboratory, and
- measure LANL's potential contribution to nonradiological air pollution in the surrounding communities.

2. Air Monitoring Network

NonRadNet samples environmental levels of nonradiological air constituents in Los Alamos

County. Species to be monitored include the following: total suspended particulate matter (TSP), particles with diameters of 10 micrometers or less (PM-10), particles with diameters of 2.5 micrometers or less (PM-2.5), volatile organic compounds (VOC), and inorganic elements on particulate matter. In 2001, the VOCs included up to 160 compounds, and the inorganics included up to 15 elements (arsenic, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, and zinc).

We based the sampling locations on EPA (40 CFR Part 58) and LANL (procedure ESH-17-207) siting criteria. Monitoring stations were designed to collect samples in the breathing zone (2 meters above ground surface). Uniform application of these criteria assures consistency, comparability, and representativeness among all air sampling locations. Good scientific judgment is always employed as the final criterion in selecting the optimal locations, in addition to the site-specific ones cited above.

Simultaneous monitoring took place in three different locations—two in Los Alamos and one in White Rock, NM. The White Rock sampling is collocated with the existing AIRNET station at the White Rock Fire Station. One Los Alamos station is collocated with the existing AIRNET station at the Los Alamos Hospital. We established one new station near the intersection of Diamond Drive and East Jemez Road, between the main technical area of the Laboratory and the population center of the Los Alamos town site.

We use existing meteorological data collected through LANL's current monitoring network to help us interpret the data and evaluate their impact. PM-10 and PM-2.5 concentrations are measured continuously and averaged over 1-hour, 3-hour, and 24-hour time periods. VOC and TSP/inorganics sampling takes place on every twelfth day to coincide with EPA's national ambient air monitoring schedule, with each sampling period lasting 24 hours. All sites commenced operation on September 22, 2001.

3. Sampling Procedures, Data Management, and Quality Assurance

Anderson GV-2360 volumetric-flow-controlled high-volume samplers collected samples for 24-hour time-integrated TSP on either Dynaweb polypropylene or Whatman cellulose 8 in. × 10 in. filters. All filters are placed in the sampler less than 48 hours before the

start of a sampling run and are recovered from the samplers within 24 hours of the end of a sampling period. We weigh all filters before deployment and again after collection. All weighing activities take place in a humidity-conditioning chamber, and filters are equilibrated for at least 24 hours before each weighing to attempt to achieve consistent absorbed water levels. We then send these TSP filters to a commercial environmental analytical chemistry laboratory in glassine envelopes under chain-of-custody for chemical analysis of up to 15 inorganic elements with both inductively coupled plasma emission spectrometry (ICPES) and inductively coupled plasma mass spectrometry (ICPMS) using EPA Methods SW 6010 and SW 6020, respectively.

A Rupprecht & Patashnick TEOM (tapered-element oscillating microbalance) Series 1400a ambient particulate monitor fitted with either PM-10 or PM-2.5 sample inlets collects continuous PM-10 and PM-2.5 concentrations (micrograms per cubic meter). The collecting instruments record the data automatically and save them electronically for subsequent downloading and transfer to an ESH-17-maintained database. We will use these data as an indicator of natural dust loading in the atmosphere and to aid in interpreting the inorganic elemental concentration data determined on the large TSP filters.

A ThermoAnderson AVOCS (Ambient Volatile Organic Collection System) collects samples of ambient air in 15-liter SUMMA Canisters owned by LANL. Before each sampling event, all canisters are precleaned and monitored for residual levels of all VOCs. After collecting an integrated 24-hour sample, taken simultaneously at all sites every 12th day per EPA procedure, we return all canisters to Severn-Trent Laboratories (STL), located in Austin, TX, under chain-of-custody for VOC determination with EPA Compendium Method TO-15. STL reports up to 160 organic compounds to ESH-17, and these data are stored within the existing AIRNET database for subsequent evaluation and interpretation.

ESH-17 personnel enter field sampling data manually on paper forms and key them into an existing database. Using calibration procedures provided by each sampling system's manufacturer, we calculate the net air volumes sampled. We then use these volumes to calculate net ambient air concentrations of TSP, VOCs, and inorganic elements.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations.

Tables 4-19 through 4-24 summarize the ambient air concentrations calculated from field and analytical data, inorganic elements, and VOCs. For many of these elements and compounds, these measurements are the first reported in an annual Environmental Surveillance Report since this series began in 1971. The summaries include

- the number of measurements (samples);
- the number of measurements that were determined to be less than their analytical detection limits;
- the minimum and maximum values (range) where two or more measurements had positive results;
- the mean value of the positive results; and
- the 1s (standard deviation) of the mean where three or more positive values were available.

b. Particulate Matter. Several previous Environmental Surveillance Reports (ESP 1971a, ESP 1971b, ESP 1986, ESP 1987, ESP 1988, and ESP 1989) include limited local TSP data. These data show annual geometric means for both Los Alamos and White Rock to be in the 20–30 $\mu\text{g}/\text{m}^3$ range, with the maximum value observed to be 242 $\mu\text{g}/\text{m}^3$ during those time periods.

In our 2001 TSP data, we observed both negative values and concentrations up to three times the previously reported maximum for individual samples. The overall station means were also a factor of ten above historical measurements. These considerations lead us to believe that the 2001 data are largely invalid, and they were rejected as not being representative of actual atmospheric conditions because they failed to meet our established quality goals. We have selected a different filter material, Whatman cellulose paper, for use during 2002, partially in an effort to improve our overall TSP measurement procedure.

We have reviewed the 24-hour average data for PM-2.5 and PM-10 collected since the start of operation of the first TEOM that we received in late May 2001. The PM-10 measurements had concentrations up to 32 $\mu\text{g}/\text{m}^3$, whereas PM-2.5 exhibited a maximum of 14 $\mu\text{g}/\text{m}^3$. These data are consistent with the historical TSP levels of 20–30 $\mu\text{g}/\text{m}^3$, further supporting our decision to reject all of the 2001 TSP data.

4. Air Surveillance

c. Inorganic Elements. Table 4-19 shows the summary of these NonRadNet measurements for 15 elements at three stations. Previous Surveillance Reports contain relatively little air concentration data for inorganic species, and most of what is available was determined using analytical procedures that have much higher detection limits than those used this year.

A common interpretive technique calls for calculating elemental ratios to the element measured that has the minimum uncertainty and is not likely to have any source besides resuspended local soil materials. Elements commonly selected for this comparison purpose include silicon, aluminum, iron, manganese, and rare earth elements. These elemental ratios are then compared with corresponding ones taken from chemical analysis of local soils or to average terrestrial crustal abundance data compiled by Vinogradov 1959, Taylor 1964, Mason 1966, and Wedepohl 1968.

With the data for the elemental content of on-site soils (ESP 2000), we developed a mean elemental concentration for on-site comparison. Unfortunately we did not foresee using this elemental ratio technique when we selected the original list of elements for chemical analysis of our new program's samples, and therefore we must employ another of the major "rock-forming" elements, such as barium. Figure 4-15 displays all our individual measurements of barium with both of the analytical methods used, further illustrating that this element is a good choice because of its consistency over the last quarter of 2001.

We have calculated a set of mean elemental ratios to barium (Ba) from our summary of the on-site soil data from the 2000 ESR in Table 4-20.

The air sample data are internally very consistent and in good agreement with our estimates from our local soils. This agreement suggests no evidence for any non-soil-derived enhancement to the soil background levels of these trace elements except for copper, antimony, and zinc. Copper is strongly enhanced, and this enhancement probably results from contributions from the high-volume pump in the sampling equipment. This effect was documented in 1970 during sampling for metals in clean marine and continental environments (Hoffman 1971). The antimony and zinc results are not so readily understood and require further study and source evaluation before we can draw firm conclusions. It is possible that the average concentrations used for local soils are in error, particularly for antimony, a difficult element to determine at natural abundance levels in soils.

As our program matures, we may add additional soil-derived elements and other elements that LANL operations might influence.

d. Volatile Organic Compounds. Tables 4-21 to 4-24 present summary data for 160 compounds at three stations. The first three of these tables contain summaries for 124 compounds where at least one positive detection was achieved at one site. The final table presents a summary for 36 compounds that have only detection limit data at all sites for all measurements.

Determining background levels for these compounds is not as easy as it is for inorganics. Organic compounds have a variety of natural and anthropogenic sources, and many of these compounds are well mixed in the troposphere. As our program matures, we hope to be able to group this large number of compounds into major source groups (e.g. fuel hydrocarbons, refrigerants, paint solvents, natural vegetation emissions, etc.) to help provide a simpler basis for evaluating seasonal variations and potential impacts from Laboratory operations.

5. Detonation and Burning of Explosives

a. Total Quantities. The Laboratory tests explosives by detonating them at firing sites operated by the Dynamic Testing Division. The Laboratory maintains monthly shot records that include the type of explosives used as well as other material expended at each site. Table 4-25 summarizes the amounts of expended materials for CY 2000 and CY 2001. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2001, the Laboratory burned 1.1 tons of high explosives.

An assessment of the ambient impacts of high-explosives testing, presented in the Site-Wide Environmental Impact Statement for Los Alamos (DOE 1999), indicates that high-explosives testing produces no adverse air quality impacts. The actual quantities of materials detonated during 2001 were less than the amounts for which impacts are analyzed in the Site-Wide Environmental Impact Statement.

6. Beryllium Sampling

a. Routine Sampling. In the early 1990s, we analyzed a limited number of AIRNET samples for beryllium in an attempt to detect potential impacts from regulated sources and releases from explosive

testing. All values were well below the New Mexico 30-day ambient air quality standard of 10 ng/m^3 . With the recent heightened interest in the health effects of beryllium, we are again analyzing AIRNET samples for this contaminant.

However, New Mexico no longer has an ambient air quality standard for beryllium for comparison with AIRNET measurements. Therefore, we selected another air quality standard to use for comparison purposes: the National Emission Standards for Hazardous Air Pollutants (NESHAP) standard of 10 ng/m^3 (40 CFR Part 61 Subpart C National Emission Standard for Beryllium) can be, with EPA approval, an alternative to meeting the emission standard for beryllium. LANL is not required to use this alternative standard because the permitted sources meet the emission standards, but we have used it in this case for comparative purposes.

We reinstituted beryllium determination at selected AIRNET sites in 1999. We continued to analyze quarterly composited samples from 29 sites for beryllium during 2001. These sites are located near potential beryllium sources or in nearby communities. Our previous results indicate that the source of beryllium in our AIRNET samples was naturally occurring beryllium in resuspended dust. Dust may be resuspended mechanically, by vehicle traffic on dirt roads or construction activities, or by the wind in dry periods.

For 2001, we calculated air concentrations including a blank subtraction as we did for the 2000 data. Air concentrations for 2001, shown in Table 4-26, are, on average, very similar to the 2000 values. Concentrations at two Area G stations again declined significantly in 2001 just as we observed during 2000. All values are 2% or less than the NESHAP standard.

The highest measured beryllium concentrations occurred at TA-54, Area G; the Los Alamos County Landfill; the Jemez Pueblo Visitor's Center; and in Santa Fe. Because none of these sites have any beryllium handling operations, the source of the beryllium is most likely from naturally occurring beryllium in the soils, resuspended by the wind or by vehicles on dirt roads and earthmoving/construction operations. TA-54, Area G, is located in the drier portion of the Laboratory, making wind resuspension a more important contributor than at other Laboratory locations. Resuspension of fine dust particles is also a common occurrence during trucking operations at the county landfill. Similarly, Jemez Pueblo has reported signifi-

cant levels of blowing dust, especially during the springtime.

Earlier in this chapter, we used the ratio of uranium-238 to uranium-234 to detect impacts from LANL because these isotopes are naturally present at a constant ratio. No comparable situation exists for beryllium because it is mono-isotopic, but the ratio of beryllium to other elements present in the soil will be relatively constant if the local sources of particulate matter are similar. We chose cerium last year as having good potential to be representative of natural soil particulate matter and unlikely to have a Laboratory source. We have now encountered difficulty with this approach during low dust loading quarters when cerium concentrations in individual samples approach or reach analytical detection limits. Beginning with the second quarter of 2001, we added manganese and strontium to our ratio effort, and, in the third quarter, we dropped cerium entirely. Even though the individual sample concentrations of manganese and strontium never approached their respective analytical detection limits, we observed significant variability in their relative abundance in soils taken from the wide area covered by our AIRNET network. Although we see no evidence of unusual levels of beryllium in any of our samples based on any of these three elemental ratios, it remains difficult to easily assess potential Laboratory impacts using this elemental ratio approach. We continue to search for other approaches.

b. Special Sampling. We performed short-term ambient air sampling for three beryllium-containing high-explosives test shots at TA-15 (Dual Axis Radiographic Hydrodynamics Test [DARHT] and Phermex) during 2001, taking TSP matter samples at 10–13 locations before and during the test. In general, the samplers ran for 24 hours. We analyzed samples for beryllium and uranium isotopes. Samples were also analyzed for inorganic soil elements: cerium, manganese, and strontium. These elements are not found in LANL emissions and so are useful in distinguishing the impacts of high-explosives tests from soils resuspended by winds.

Based on 7 or 8 days of 24-hour sampling on non-high-explosives test shot days, the average beryllium concentration at the short-term sampling locations was $0.036 (\pm 0.0005) \text{ ng/m}^3$. The standard deviation of these 56 samples was 0.041 ng/m^3 . The average value was somewhat higher, but consistent with quarterly average beryllium concentrations measured at AIRNET stations. The higher concentration may

4. Air Surveillance

reflect sampling locations near areas where beryllium has been used historically or near areas where soil disturbing activities (other than high-explosive testing) occur.

We reviewed the ten highest 24-hour beryllium concentrations. Three occurred on days with no beryllium-containing high-explosives tests. One additional beryllium measurement in the highest ten group occurred in a wind direction more than 90 degrees from the direction at the time of the test. Thus, the short-term beryllium air concentration data show significant variability that we need to quantify; they do not appear to be related to high-explosive testing.

We used the TA-49 and TA-6 meteorological tower wind direction data to identify air sample locations downwind of the tests at the time of the test shots. Two air samples for one high-explosives test shot and one sample from another high-explosive test shot showed elevated beryllium and uranium based on comparisons with average air concentrations measured on non-test-shot days. Other samples taken during these tests did not demonstrate both elevated beryllium and uranium air concentrations. The beryllium concentrations measured were 0.700, 0.167, and 0.143 ng/m³ (without subtraction for background). Each of these air concentrations was measured on-site at TA-15, to the north of the test location.

E. Meteorological Monitoring (*Scot Johnson*)

1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, we measure a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dewpoint, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Baars et al., 1998) provides details of the meteorological monitoring program [an electronic copy of the Meteorological Monitoring Plan is available on the Internet at www.weather.lanl.gov/monplan/mmp1998.pdf].

2. Climatology

Los Alamos has a temperate, semiarid mountain climate. However, large differences in locally ob-

served temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site. Four distinct seasons occur in Los Alamos. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized below are from analyses provided in Bowen (1990 and 1992) as well as from historical meteorological databases maintained by the Meteorology Project of ESH-17.

Temperatures at Los Alamos are characterized by wide daily variations (a 23°F range on average) because of the semiarid climate. Atmospheric moisture levels are low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and long-wave radiative cooling of the earth at night that is not ameliorated by downward long-wave radiation that would occur in the presence of clouds and water vapor. The daily fluctuation in temperature is therefore high in Los Alamos. Surrounding communities such as White Rock and Española see even greater fluctuations because they receive a cool nighttime flow that drains from the Pajarito Plateau as it slopes downward to the east towards the Rio Grande river and a nighttime flow southward down the Rio Grande valley itself.

Winter temperatures range from 30°F to 50°F during the daytime and from 15°F to 25°F during the nighttime, with a record low temperature of -18°F recorded in 1963. The Sangre de Cristo Mountains to the east of the Rio Grande Valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. Winds during the winter are relatively light, so extreme wind chills are uncommon. Summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime, with a record high temperature of 95°F recorded in 1998.

The average annual precipitation (which includes both rain and the water equivalent for frozen precipitation) from 1931 to 2000 is 18.3 in. The average annual snowfall is 52.3 in. Winter precipitation in Los Alamos is often due to storms approaching from the Pacific Ocean or to cyclones forming and/or intensifying leeward of the Rocky Mountains. The snow is usually a dry fluffy powder, with an equivalent water-to-snowfall ratio of about 1:20. Large snowfalls may occur locally as a result of orographic lifting of the storms by the Jemez Mountains. The record single-day

snowfall is 22 in., which occurred in 1978 and 1987. The record single-season snowfall is 153 in. set in 1986–1987. Any resident and skier knows too well that annual snowfall varies greatly from year to year, but decadal variability in snowfall is surprisingly low—only a few inches variation per year on the decadal average. The exception is the 1980s, during which the annual average snowfall was 77 inches compared with the annual average snowfall since 1931 (including the 80s) of 52.3 in.

The two months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season. Afternoon thunderstorms form as moist air advected from the Pacific Ocean and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the USA, is estimated at 7 to 22 strikes per square mile per year (from an internal communication by Stone in 1998). ESH-17 began measuring lightning activity in 1998, and, according to this small sample set, 54% of the detected local lightning activity occurred during July and August. Lightning is most commonly observed during warmer months; 93% of the lightning activity counted since 1998 occurred between the months of June and September.

The complex topography of Los Alamos influences local wind patterns, notable in the absence of large-scale disturbances. Often a distinct diurnal cycle of winds is observed. As air close to the ground is heated during the day, it tends to be displaced by cooler air from aloft and tends to rise and flow upslope along the ground—“anabatic” flow. During the night, cool air that forms close to the ground tends to flow downslope—“katabatic” flow. Daytime upslope (anabatic) flow of heated air on the Pajarito Plateau adds a southerly component to the winds on the plateau as it flows up the Rio Grande valley. Night-time downslope (katabatic) flow of cooled air from the mountains and plateau adds a light westerly to northerly component to local winds. Flow in the east-west oriented canyons that interrupt the Pajarito Plateau is often aligned with the canyons, and so winds are usually from the west at night as katabatic flow and from the east during the day.

3. Monitoring Network

A network of six towers gathers meteorological data (winds, atmospheric state, precipitation, and

fluxes) at the Laboratory (see Meteorological Network [Figure 4-16] and the Meteorological Monitoring Plan [Baars et al., 1998]). Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), one is in a canyon (TA-41), and one is on top of Pajarito Mountain (PJMT). The TA-6 tower is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is also located adjacent to the TA-6 meteorological tower. Precipitation is also measured at TA-16, TA-74, and in the North Community of the Los Alamos town site.

4. Sampling Procedures, Data Management, and Quality Assurance

We site instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects (from trees and structures) on wind and precipitation measurements. Open fields also prevent the obstruction of radiometers measuring solar and terrestrial radiation (ultraviolet to infrared spectra).

Temperature and wind are measured at multiple levels on open lattice towers. Instruments are positioned on west-pointing booms (toward the prevailing wind), at a distance of at least two times the tower width (to reduce tower wake effects). The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements, which support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar heating effects.

Data loggers at the tower sites sample most of the meteorological variables at 0.33 Hz, store the data, then average the samples over a 15-minute period, and transmit the data to a Hewlett Packard workstation by telephone or cell phone. The workstation automatically edits measurements that fall outside of allowable ranges. Time-series plots of the data are also generated for a meteorologist's data quality review. Daily statistics of certain meteorological variables (i.e., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. Once daily over the past 45 years, a similar set of statistics has been telephoned to the National Weather Service. Observers log cloud type and percentage cloud cover three times daily.

4. Air Surveillance

All meteorological instruments are annually refurbished and calibrated during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify that they remained in calibration while in service. All instrument calibrations are traceable to the National Institute of Standards and Technology. An external audit is typically performed once every 2 to 3 years, with the most recent performed during the summer of 1999. Results indicated no significant anomalies with the instruments in the network.

5. Analytical Results

The 2001 Weather Summary (Figure 4-17) presents a graphical summary of Los Alamos weather for 2001. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals, compared with monthly normals (averaged from 1931–2000).

Climatologically, Los Alamos weather for 2001 continued a four-year trend of warm temperatures and a dryer-than-normal climate. The average annual temperature of 49.4°F exceeded the normal annual average of 48.2°F by 1.2 degrees. The total precipitation in 2001 was 79% of normal at 14.4 inches. These warm and dry conditions do not appear, however, to be unusual with respect to the 70-year climate history. The area has experienced many warmer years and many drier years. Monthly precipitation totals were above normal early in the year, somewhat below average during the July–August rainy season, and well below normal from September throughout the remainder of the year. The annual snowfall total was 5% above normal at 55 inches with monthly snowfall totals below normal for every month except for January, which was over three times the normal January snowfall.

Wind statistics, based upon 15-minute averaged wind observations at the four Pajarito Plateau towers and the Pajarito Mountain tower for 2001, appear as wind roses in Figure 4-18. The wind roses depict the percentage of time that the wind blows from each of 16 compass rose points, as well as the distribution of wind speed for each of the 16 directions, represented by shaded wind rose barbs.

Daytime winds (sunrise to sunset) measured by the four Pajarito Plateau towers were predominately from the south, consistent with the typical upslope flow of heated daytime air (see Figure 4-19) moving up the Rio Grande Valley. Nighttime winds (sunset to sunrise)

on the Pajarito Plateau were lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope katabatic flow of cooled mountain air (see Figure 4-20). Winds atop Pajarito Mountain are more representative of upper-level flows and primarily ranged from the northwest to the southwest, mainly because of the prevailing westerly winds.

6. Heavy Rainfall Events Before and After the Cerro Grande Fire

The Cerro Grande fire burned nearly all of the watersheds above LANL and Los Alamos. As a result, the ability of the soil and vegetation in the watersheds to absorb water has been drastically reduced. These watersheds feed streams that follow the canyons eastward through the Laboratory and town toward the Rio Grande. So, in the aftermath of the fire, the danger of flash flooding affecting LANL and Los Alamos during the summer rainy season increased substantially. A number of measures have been taken to alleviate the danger of flooding, including building dams, clearing culverts, and breaking up and reseed-ing the hydrophobic layer of soil upstream of Los Alamos.

To provide early warning of flash flood danger, the Bureau of Land Management (BLM) placed nine Remote Automated Weather System (RAWS) stations in threatened watersheds that feed the following canyons: Santa Clara (Upper Santa Clara Canyon and Santa Clara Canyon stations), Garcia, Rendija (Guaje Canyon station), Pueblo, Los Alamos (Quemazon and Upper Los Alamos stations), Pajarito, and Water Canyon (see Figure 4-21). The stations are equipped to send a radio warning to local authorities if they measure a rain total of 0.16 inches in a given ten-minute period. The LANL RAWS station data are available online at <http://www.wrcc.dri.edu/losalamos/> and through a LANL meteorologist.

The community did not sustain serious flood damage during the first rainy season following the fire in May of 2000. Although significant rainfall events did occur during the summer of 2000, the heaviest of these amounted to 0.58 inches per hour. Approximately 90% of rainy seasons can be expected to yield higher one-hour rainfalls. Heavy rainfall events returned during the summer of 2001, however, and on July 2, the volunteer fire station at 4017 Arkansas Street in the North Community area of Los Alamos

measured 1.06 inches of rain in one hour. The rain event lasted about one hour, which is typical of events during the summer rainy season. But the unusually large drainage in a small canyon nearby washed away North Road. It is estimated that to replace North Road and to employ measures to prevent further flooding damage in that area will cost \$26M.

Was the amount of rain that fell from about 4:30 to 5:30 p.m. on July 2 more than usual? Or can we expect another such event in the near future? July 2 saw one of the heaviest rainfall events measured by the North Community rain gauge since it began operating in 1996. But, during the six years that the rain gauge has been in operation, even heavier rains have fallen in the North Community on two occasions. On July 3, 1998, between 3:30 and 4:30 p.m., 1.12 inches fell, and on July 9, 1999, between 2:15 and 3:15 p.m., 1.24 inches fell. Based on the short history of the North Community rain gauge, one can assume that a rainstorm as heavy or heavier than the rainfall event of July 2 can be expected once every other summer. This assumption is consistent with Bowen (1990) who concluded, based on an extreme event analysis using nine years of data from TA-59, that a 1-inch per hour rainfall event will recur in Los Alamos once every two years.

A rain gauge at TA-6 about one mile south of Omega Bridge and the town site corroborates this finding and adds some insight. In 12 years of operation, this gauge has measured rain events of at least one inch per hour on five occasions, suggesting the occurrence of a rain event similar to the July 2, 2001, rain event once every two to three years. These events are not spaced evenly in time, however, with one rain event occurring during each summer of 1990, 1992, and 1993 and two events in 1991, but none during the eight summers from 1994 to 2001. In addition, heavy rain events at one station are usually not coincident with heavy rain events at other stations only a few miles away. For example, during the disastrous rain event of July 2, 2001, the gauge at TA-6 measured only 0.64 inches. Furthermore, in comparison with the maximum hourly rain event of 1.24 inches at the North Community rain gauge, the heaviest hourly rainfall measured at TA-6 is 1.34 inches, which fell on July 22, 1991, between 5:45 and 6:45 p.m. Because the 12-year TA-6 sample set is twice as large as the North Community data set, it can be expected to contain a slightly larger maximum event.

The RAWS stations did not measure as much rainfall on July 2, 2001. The Pueblo station measured

0.7 inches of rainfall between 4 and 5 p.m. (and none after 5 p.m.). The rainfall at the Pueblo station was the heaviest hourly rainfall that any of the nine RAWS stations measured on July 2, which is not unexpected because the washout of North Road was due to rainfall onto the Pueblo Canyon watershed. In comparison with the July 2 TA-6 measurement of 0.64 inches, the Pajarito station, which lies about 2.7 miles west northwest of TA-6, measured only 0.37 inches between 5:00 and 6:00 p.m. The average daily total of the nine RAWS stations for July 2 was a relatively mild 0.58 inches. The monthly total for the RAWS stations averaged 3.9 inches, however, far exceeding the July total at TA-6 of 2.5 inches and 2.1 inches at North Community. This result may be expected because the average RAWS station is about 1300 ft higher than TA-6 and the North Community rain gauge. The relatively light rainfall measured by the RAWS stations on July 2 attests to the high spatial variability of heavy rainfall in this area.

Finally, it should be noted that rain events amounting to about 0.85 inches in one hour, if not quite as sizeable as the July 2 event as measured by the North Community rain gauge, typically occur one or two times per summer (although not even a single time in some summers, as was the case in 2000). This event rate means that significantly heavy and dangerous rainfall events can be expected to occur at least once during almost every summer rainy season, with events exceeding that of July 2, 2001, once every two to three years and surpassing it by 25% one time every decade.

F. Quality Assurance Program in the Air Quality Group (*Ernie Gladney, Angelique Luedeker, and Terry Morgan*)

1. Quality Assurance Program Development

During 2001, ESH-17 revised three quality plans that affect collection and use of air quality compliance data. We also revised approximately 23 implementing procedures to reflect the constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that ESH-17 processes perform satisfactorily. All current quality related documents are available on the ESH-17 public Web site (www.lanl.gov/orgs/rres/maq/index.htm).

4. Air Surveillance

2. Field Sampling Quality Assurance

We maintained the overall QA of this portion of the program through the rigorous use of carefully documented procedures governing all aspects of the sample collection program. Particulate and water vapor samples are

- taken on commercially available media of known performance,
- collected under common EPA chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and
- prepared in a secure and radiologically clean laboratory for shipment.

They are then delivered to internal and external analytical laboratories under full chain-of-custody utilizing secure FedEx shipment to all external vendors, and we track them at all stages of their collection and analysis through the AIRNET and RADAIR relational databases. All NonRadNet program samples are tracked within the AIRNET database. A complete suite of blanks also goes with each set of samples, to include matrix blanks, trip blanks, and process blanks (where applicable). All blanks are submitted to analytical suppliers for chemical measurements.

We assess field sampling completeness every time the analytical laboratory returns the AIRNET bi-weekly gross alpha/beta data. We check RADAIR field sampling completeness each week upon receipt of the gross alpha/beta and tritium bubbler data and NonRadNet field sampling completeness each 12-day sampling period upon receipt of the inorganic or VOC data sets. All these calculations are performed for each ambient air and stack sampling site and are included in the quality assessment memo that the Chemistry Coordination and Information Management staff prepares to evaluate every data group received from a supplier.

3. Analytical Laboratory Quality Assessment

Specific Statements of Work (SOWs) govern the acquisition and delivery of analytical chemistry services after the Data Quality Objective (DQO) process has identified and quantified our program objectives. These SOWs are sent to potentially qualified suppliers who then undergo a pre-award on-site assessment by experienced and trained ESH-17

quality systems and chemistry laboratory assessors. The assessors primarily use SOW specifications, professional judgment, and quality system performance at each lab (including recent past performance on nationally conducted performance evaluation programs) to award contracts for specific types of radiochemical organic and inorganic analyses. Each laboratory conducts its chain-of-custody and analytical processes under its own quality plans and procedures. ESH-17 submits independently prepared blind spiked tritium samples with each tritium sample set. The analytical laboratory returns preliminary data to ESH-17 by e-mail in an Electronic Data Deliverable (EDD) of specified format and content. Each set of samples contains all the internal QA/QC data generated by the analytical laboratory during each phase of chemical analysis (including laboratory control standards, VOC surrogate compounds, process blanks, matrix spikes, duplicates, and replicates, where applicable). ESH-17 uploads all data electronically into either the AIRNET or RADAIR databases (NonRadNet data are stored within AIRNET) and immediately subjects the data to a variety of quality and consistency checks: we calculate analytical completeness, track and trend all blank and control sample data, and include all parameters in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in each database, and we prepare periodic reports to management.

We changed the tritium blind matrix spike samples used in the AIRNET program in 2001 from simple spiked waters to a more representative matrix of spiked water evaporated onto silica gel. See Section A.4.c. of this chapter for a detailed discussion of the results of this change.

4. Field Data Quality Assessment Results

Field data completeness for AIRNET, NonRadNet, and Stacks was 100%. Sampler run time was greater than 98% for each network during 2001.

5. Analytical Data Quality Assessment Results

The Clean Air Act requires an EPA-compliant program of QC samples as an integral part of the sampling and analysis process. Table 4-27, Table 4-28, and Table 4-29 document the types and numbers of QC samples run for the overall sampling program.

Our sample and data management procedures document the specific evaluations of each type of QC

sample for each analytical measurement. Tables 4-30 through 4-35 show the evaluation criteria and overall outcome of these QC tests.

All QC data are tracked and trended and reported in specific QC Evaluation memos that go to project staff along with each set of analytical data received from our chemistry laboratories.

6. Analytical Laboratory Assessments

During 2001, one internal and three external laboratories performed all chemical analyses reported for AIRNET, NonRadNet, and RADAIR samples. The Wastren-Grand Junction analytical laboratory (associated with the DOE's Grand Junction Project Office) provided biweekly gross alpha, gross beta, and isotopic gamma analytical services for AIRNET. Biweekly AIRNET tritium analytical services came from Paragon Analytics, Inc., Fort Collins, CO. Wastren-Grand Junction also provided analytical chemistry services for alpha-emitting isotopes (americium, plutonium, polonium, thorium, and uranium), beta-emitting isotopes (lead-210), and stable beryllium on AIRNET quarterly composite samples. In addition, they performed all inorganic elemental analyses for the AIRNET and NonRadNet programs. Severn-Trent Laboratories, Austin, TX, analyzed the gas collected in SUMMA Canisters for the NonRadNet program for VOCs. Our on-site Health Physics Analytical Laboratory (ESH-4) performed all instrumental analyses (gross alpha, gross beta, isotopic gamma, and tritium) reported for stack emissions and in-stack samples. Semester composites of in-stack filters were analyzed for alpha- and beta-emitting isotopes at the Wastren-Grand Junction site.

ESH-17 also performed formal on-site assessments at all four laboratories during 2001. Three of these analytical laboratories participated in national performance evaluation studies during 2001 (no such national studies are known for VOCs). The DOE Environmental Measurements Laboratory in New York, NY, sponsors a DOE-wide environmental intercomparison study, sending spiked air filters (among other matrices) twice a year to the participating laboratories. Other commercial and state agencies also produce materials and sponsor a wide variety of intercomparison programs. Each assessment report includes the detailed results of these performance evaluations (Lochamy et al., 2001; Gladney and Luedeker 2001; Gladney and Morgan 2002; and

Morgan et al., 2002). Overall, the study sponsors judged our analytical labs that participated in these national studies to have acceptable performance for all analytes attempted in all matrices.

G. Unplanned Releases

During 2001, the Laboratory had no instances of increased airborne emissions of radioactive or nonradioactive materials that required reporting to either the New Mexico Environment Department or the EPA.

Although no reporting thresholds were exceeded, one radionuclide release to the air was noteworthy. On January 31, 2001, WETF released approximately 7600 Ci of tritium gas (HT). This single release contributed over 80% of the total Laboratory tritium emissions for 2001. The release occurred when a container of legacy waste, originally thought to contain less than 50 curies of tritium, failed during processing. Failure of the container released the high-purity tritium gas into the stack ventilation system. The off-site dose from this release was calculated using an emergency response model (MIDAS) to be 0.02 mrem at the site boundary. This dose was well below any regulatory thresholds. The Occurrence Report <http://drambuie.lanl.gov/~esh7/Finals/tritfacils/0201.html> contains a complete description of the event.

H. Special Studies—Neighborhood Environmental Watch Network Community Monitoring Stations

Neighborhood Environmental Watch Network (NEWNET) is a LANL program for radiological monitoring in local communities. It establishes gamma-radiation monitoring stations in local communities and near radiological sources. The data from all the stations are available to the public with, at most, a 24-hour delay. The NEWNET Web page also includes a Spanish language version.

During 2001, we upgraded two NEWNET stations with new Campbell CR10X data loggers and telephone modems to replace the 15-year-old Synergetics 3400-series data loggers and satellite transmitters. The result has been a significant decrease in the noise, especially the spikes that limited the accuracy. As a test of the accuracy of the new system, we used one of the new stations, at East Gate, north of TA-53, to estimate the gamma dose for three cases, as follows.

The first two cases are estimates of the external gamma radiation at East Gate from short-lived

4. Air Surveillance

nuclides from TA-53, primarily oxygen-15 (2-minute half-life) and carbon-11 (20-minute half-life.)

From November 3 to November 12, 2001, the gamma background at East Gate was 16.6 ± 0.1 $\mu\text{R/h}$. Emissions of activated air caused the dose rate to increase to 19 ± 3 $\mu\text{R/h}$ when the wind carried this air from the LANSCE stack to the NEWNET station. By integrating the dose rate as a function of time, we estimated that the total dose was 0.04 ± 0.02 mrem above background. For comparison, the CAP88 program calculated the dose for this period as 0.28 mrem.

Similarly, from November 13 to November 26, the background at East Gate was 16.7 ± 0.1 $\mu\text{R/h}$, the total dose estimated from the NEWNET data was 0.11 ± 0.03 mrem above background, and the CAP88 dose was 0.22 mrem.

The third case involves work on a 1500-Ci cesium-137 source at TA-53 on September 17, 2001, which caused the dose rate at East Gate to increase from 16.44 ± 0.01 $\mu\text{R/h}$ to 20.5 ± 0.1 $\mu\text{R/h}$ for 2.5 h. The total dose, estimated from the NEWNET data, was 10.1 ± 0.3 μrem above background. Because this did not involve airborne radionuclides, this dose is not calculated by CAP88, and NEWNET provides the only estimate.

These three examples demonstrate the accuracy of the upgraded NEWNET system. It is now possible to use NEWNET to measure gamma dose rates with an accuracy of 1 mrem/year. More information about NEWNET and the data are available at <http://newnet.LANL.gov/> on the World Wide Web.

I. Tables

Table 4-1. Average Background Concentrations of Radioactivity in the Regional^a Atmosphere

	Units	EPA Concentration Limit ^b	Annual Averages ^d				
			1997	1998	1999	2000	2001
Gross Alpha	fCi/m ³	NA ^c	0.7	0.8	1.0	1.0	0.8
Gross Beta	fCi/m ³	NA	14.1	12.4	13.4	13.0	13.9
Tritium ^e	pCi/m ³	1,500	0.7	0.5	0.5	0.8	-0.1
²³⁸ Pu	aCi/m ³	2,100	0.0	0.1	-0.2	0.0	0.0
^{239,240} Pu	aCi/m ³	2,000	-0.2	0.4	0.1	0.0	0.1
²⁴¹ Am	aCi/m ³	1,900	0.2	0.3	-0.2	0.3	-0.2
²³⁴ U	aCi/m ³	7,700	14.1	12.9	16.1	17.1	17.9
²³⁵ U	aCi/m ³	7,100	0.6	0.9	1.2	0.9	1.3
²³⁸ U	aCi/m ³	8,300	12.2	12.8	15.2	15.9	17.7

^aData from regional air sampling stations operated by LANL during the last five years.

Locations can vary by year.

^bEach EPA limit equals 10 mrem/yr.

^cNA = not available.

^dGross Alpha and Beta Annual Averages are calculated from gross air concentrations. All other Annual Averages are calculated from net air concentrations.

^eTritium Annual Averages have been corrected for the tritium lost to bound water in the silica gel media.

4. Air Surveillance

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 2001

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	Sample Standard Deviation
Regional Stations						
01 Española	26	0	2.07	0.40	0.86	0.39
03 Santa Fe	26	0	1.68	0.35	0.76	0.35
55 Santa Fe West (Buckman Booster #4)	26	0	2.15	0.29	0.73	0.39
56 El Rancho	26	0	2.02	0.36	0.84	0.43
Pueblo Stations						
41 San Ildefonso Pueblo	25	0	1.97	0.41	0.86	0.36
59 Jemez Pueblo-Visitor's Center	26	0	1.95	0.45	0.89	0.45
Perimeter Stations						
04 Barranca School	26	0	1.74	0.22	0.67	0.30
05 Urban Park	26	0	1.78	0.34	0.74	0.32
06 48th Street	26	0	2.08	0.38	0.67	0.35
08 McDonald's Restaurant	26	0	2.13	0.31	0.71	0.38
09 Los Alamos Airport	26	0	2.11	0.35	0.72	0.34
10 East Gate	26	0	2.15	0.38	0.77	0.36
11 Well PM-1 (E. Jemez Road)	26	0	1.79	0.31	0.67	0.31
12 Royal Crest Trailer Court	26	0	1.92	0.31	0.66	0.33
13 Rocket Park	26	0	1.79	0.34	0.72	0.33
14 Pajarito Acres	26	0	2.14	0.24	0.75	0.38
15 White Rock Fire Station	26	0	2.00	0.29	0.78	0.35
16 White Rock Nazarene Church	26	0	2.07	0.25	0.74	0.36
17 Bandelier Fire Lookout	26	0	1.82	0.39	0.69	0.29
26 TA-49	26	0	1.92	0.23	0.65	0.32
32 County Landfill	26	0	1.13	0.37	0.65	0.22
54 TA-33 East	26	0	2.01	0.38	0.78	0.41
60 LA Canyon	26	0	2.29	0.35	0.67	0.38
61 LA Hospital	26	0	2.43	0.42	0.86	0.41
62 Crossroads Bible Church	26	1	2.48	0.09	0.77	0.45
63 Monte Rey South	26	0	2.12	0.25	0.72	0.37
66 Los Alamos Inn-South	26	0	2.08	0.40	0.72	0.33
67 TA-3 Research Park	26	0	2.27	0.34	0.91	0.38
68 Airport Road	2	0	0.70	0.61	0.66	0.07
80 Western Arizona Street	12	0	2.28	0.41	0.82	0.51
90 East Gate-Backup	9	0	1.75	0.42	0.78	0.43
TA-15 and TA-36 Stations						
76 TA-15-41	26	0	2.21	0.30	0.71	0.36
77 TA-36 IJ Site	25	0	2.53	0.26	0.68	0.43
78 TA-15-N	26	0	1.91	0.32	0.72	0.32
TA-21 Stations						
20 TA-21 Area B	26	0	1.79	0.24	0.59	0.29
71 TA-21.01 (NW Bldg 344)	26	0	2.72	0.28	0.76	0.46

4. Air Surveillance

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 2001 (Cont.)

Station Location		Number of Measurements	Number of	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	Sample Standard Deviation
			<Uncertainty				
TA-54 Area G Stations							
27	Area G (by QA)	26	0	1.77	0.48	0.79	0.29
34	Area G-1 (behind trailer)	26	0	1.79	0.57	0.90	0.29
35	Area G-2 (back fence)	26	0	1.44	0.31	0.70	0.26
36	Area G-3 (by office)	26	0	2.49	0.42	0.75	0.40
45	Area G/South East Perimeter	26	0	1.75	0.45	0.90	0.27
47	Area G/North Perimeter	26	0	2.17	0.53	0.84	0.34
50	Area G-expansion	26	0	1.83	0.50	0.88	0.29
51	Area G-expansion pit	26	0	2.37	0.42	0.83	0.37
Other On-Site Stations							
23	TA-5	26	0	2.03	0.35	0.76	0.35
25	TA-16-450	26	0	2.55	0.28	0.75	0.42
30	Pajarito Booster 2 (P-2)	26	0	2.06	0.31	0.82	0.39
31	TA-3	26	0	2.14	0.29	0.81	0.39
49	Pajarito Road (TA-36)	26	0	1.97	0.31	0.76	0.33
QA Stations							
38	TA-54 Area G-QA (next to #27)	26	0	2.00	0.33	0.77	0.35
39	TA-49-QA (next to #26)	26	0	1.37	0.22	0.61	0.24
Group Summaries							
Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	95% Confidence Interval ^a	Sample Standard Deviation
Regional	104	0	2.15	0.29	0.80	±0.08	0.39
Pueblo	51	0	1.97	0.41	0.88	±0.11	0.40
Perimeter	595	1	2.48	0.09	0.73	±0.03	0.35
TA-15 and TA-36	77	0	2.53	0.26	0.70	±0.08	0.37
TA-21	52	0	2.72	0.24	0.67	±0.11	0.39
TA-54 Area G	208	0	2.49	0.31	0.83	±0.04	0.32
Other On-Site	130	0	2.55	0.28	0.78	±0.06	0.37

Concentration Guidelines

Concentration Guidelines are not available for gross alpha concentrations.

^a95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 2001

Station Location		Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	Sample Standard Deviation
Regional Stations							
01	Española	26	0	25.6	10.2	14.8	4.2
03	Santa Fe	26	0	22.5	8.2	12.8	3.7
55	Santa Fe West (Buckman Booster #4)	26	0	23.3	8.4	13.5	3.8
56	El Rancho	26	0	26.5	8.7	14.5	4.7
Pueblo Stations							
41	San Ildefonso Pueblo	25	0	21.7	9.2	13.7	3.5
59	Jemez Pueblo-Visitor's Center	26	0	21.9	6.5	13.9	3.6
Perimeter Stations							
04	Barranca School	26	0	21.4	7.8	12.2	3.0
05	Urban Park	26	0	20.6	7.7	11.6	2.5
06	48th Street	26	0	22.0	6.7	11.1	3.1
08	McDonald's Restaurant	26	0	24.4	5.8	12.4	4.0
09	Los Alamos Airport	26	0	26.0	8.0	12.4	3.6
10	East Gate	25	0	26.7	8.4	13.0	3.9
11	Well PM-1 (E. Jemez Road)	26	0	21.6	6.5	12.0	3.1
12	Royal Crest Trailer Court	26	0	23.4	8.1	12.5	3.4
13	Rocket Park	26	0	23.5	8.2	13.1	3.7
14	Pajarito Acres	26	0	23.1	7.7	12.4	3.7
15	White Rock Fire Station	26	0	25.2	8.0	13.2	3.8
16	White Rock Nazarene Church	26	0	23.5	7.9	12.8	3.6
17	Bandelier Fire Lookout	26	0	22.8	8.0	13.1	3.6
26	TA-49	26	0	23.1	6.9	11.6	3.2
32	County Landfill	26	0	20.2	5.0	11.0	3.4
54	TA-33 East	26	0	22.9	8.6	13.3	3.7
60	LA Canyon	26	0	24.2	7.6	12.1	3.3
61	LA Hospital	26	0	26.2	8.1	13.2	3.5
62	Crossroads Bible Church	26	0	25.3	2.6	12.9	4.1
63	Monte Rey South	26	0	24.0	7.9	12.7	3.6
66	Los Alamos Inn-South	26	0	24.2	7.7	12.3	3.4
67	TA-3 Research Park	26	0	23.6	8.6	13.1	3.1
68	Airport Road	2	0	13.8	13.0	13.4	0.6
80	Western Arizona Street	12	0	26.3	9.3	14.1	4.3
90	East Gate-Backup	9	0	21.3	12.0	14.6	2.7
TA-15 and TA-36 Stations							
76	TA-15-41	26	0	25.0	7.3	12.5	3.6
77	TA-36 IJ Site	25	0	23.6	7.3	12.5	3.3
78	TA-15-N	26	0	23.3	7.9	12.4	3.2
TA-21 Stations							
20	TA-21 Area B	26	0	21.4	7.5	12.1	2.9
71	TA-21.01 (NW Bldg 344)	26	0	23.3	8.2	12.7	3.4

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	26	0	24.1	7.8	12.3	3.5
34 Area G-1 (behind trailer)	26	0	23.9	2.7	12.2	4.3
35 Area G-2 (back fence)	26	0	22.8	7.2	12.1	3.4
36 Area G-3 (by office)	26	0	25.4	7.7	12.3	3.8
45 Area G/South East Perimeter	26	0	22.3	5.8	12.6	3.7
47 Area G/North Perimeter	26	0	22.6	8.1	12.6	3.7
50 Area G-expansion	26	0	23.3	2.3	13.1	4.4
51 Area G-expansion pit	26	0	26.4	7.9	12.6	3.8
Other On-Site Stations						
23 TA-5	26	0	23.5	7.9	12.8	3.5
25 TA-16-450	26	0	27.1	7.8	12.4	3.7
30 Pajarito Booster 2 (P-2)	26	0	24.3	7.4	12.7	3.7
31 TA-3	26	0	21.4	8.0	12.0	2.9
49 Pajarito Road (TA-36)	26	0	23.5	7.4	12.6	3.3
QA Stations						
38 TA-54 Area G-QA (next to #27)	26	0	23.9	7.7	12.2	3.6
39 TA-49-QA (next to #26)	26	0	20.8	7.0	11.7	3.0

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	95% Confidence Interval ^a	Sample Standard Deviation
Regional	104	0	26.5	8.2	13.9	±0.8	4.2
Pueblo	51	0	21.9	6.5	13.8	±1.0	3.5
Perimeter	595	0	26.7	2.6	12.5	±0.3	3.5
TA-15 and TA-36	77	0	25.0	7.3	12.4	±0.7	3.3
TA-21	52	0	23.3	7.5	12.4	±0.9	3.1
TA-54 Area G	208	0	26.4	2.3	12.5	±0.5	3.8
Other On-Site	130	0	27.1	7.4	12.5	±0.6	3.4

Concentration Guidelines

Concentration guidelines are not available for gross beta concentrations.

^a95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 2001

Station Location		Number of Measurements	Number of Measurements <Uncertainty	Maximum (pCi/m ³)	Minimum (pCi/m ³)	Mean (pCi/m ³)	Sample Standard Deviation
Regional Stations							
01	Española	26	26	2.3	-1.9 ^a	0.0	0.9
03	Santa Fe	26	26	1.6	-1.9	-0.1	0.9
55	Santa Fe West (Buckman Booster #4)	26	25	5.0	-2.7	0.0	1.4
56	El Rancho	26	26	2.7	-2.8	-0.1	1.0
Pueblo Stations							
41	San Ildefonso Pueblo	25	24	13.3	-1.9	1.0	2.8
59	Jemez Pueblo-Visitor's Center	26	26	1.7	-1.7	0.0	0.9
Perimeter Stations							
04	Barranca School	26	15	4.8	0.2	2.0	1.3
05	Urban Park	25	20	3.7	-0.8	1.3	0.9
06	48th Street	25	21	4.3	-0.5	1.4	1.1
08	McDonald's Restaurant	26	1	60.1	1.3	13.8	14.5
09	Los Alamos Airport	26	0	15.4	3.3	5.7	2.5
10	East Gate	26	4	12.3	1.7	5.3	3.4
11	Well PM-1 (E. Jemez Road)	26	14	5.0	0.3	2.4	1.2
12	Royal Crest Trailer Court	26	9	10.2	0.0	3.1	2.2
13	Rocket Park	26	7	13.4	1.0	4.7	3.6
14	Pajarito Acres	26	15	10.3	0.2	2.7	2.2
15	White Rock Fire Station	26	11	6.3	0.4	2.7	1.5
16	White Rock Nazarene Church	26	5	19.5	1.1	6.6	6.0
17	Bandelier Fire Lookout	26	8	11.8	0.4	3.8	2.4
26	TA-49	26	8	25.2	-0.3	5.3	4.8
32	County Landfill	26	11	10.8	1.2	3.1	2.2
54	TA-33 East	26	9	10.9	-0.2	3.3	2.6
60	LA Canyon	26	2	30.9	0.8	7.2	7.3
61	LA Hospital	26	13	7.0	-0.3	2.5	1.5
62	Crossroads Bible Church	26	11	12.2	0.9	3.4	2.4
63	Monte Rey South	26	9	5.7	0.4	2.6	1.4
66	Los Alamos Inn-South	26	2	39.9	1.0	8.3	8.9
67	TA-3 Research Park	26	20	4.1	-0.2	1.8	0.9
68	Airport Road	2	0	6.8	3.6	5.2	2.2
80	Western Arizona Street	11	10	1.7	-0.2	0.7	0.6
90	East Gate-Backup	9	0	12.3	2.9	7.1	3.2
TA-15 and TA-36 Stations							
76	TA-15-41	26	18	6.1	-0.7	2.0	1.6
77	TA-36 IJ Site	26	13	5.2	0.1	2.5	1.3
78	TA-15-N	26	13	6.0	-0.1	2.5	1.6
TA-21 Stations							
20	TA-21 Area B	26	0	18.9	3.2	8.0	5.0
71	TA-21.01 (NW Bldg 344)	26	2	16.2	1.9	6.4	3.7

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (pCi/m ³)	Minimum (pCi/m ³)	Mean (pCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	26	0	104.6	1.8	33.2	31.7
34 Area G-1 (behind trailer)	26	0	56.0	2.3	25.8	16.0
35 Area G-2 (back fence)	26	0	7316.1	12.5	1826.5	2273.4
36 Area G-3 (by office)	26	0	82.7	5.2	42.2	29.0
45 Area G/South East Perimeter	26	0	55.0	2.0	23.2	16.5
47 Area G/North Perimeter	26	1	61.1	1.2	23.8	20.5
50 Area G-expansion	26	0	47.8	2.3	19.8	14.9
51 Area G-expansion pit	26	0	49.8	2.7	20.2	14.3
53 TA-54 MDA-H	19	3	70.1	3.1	28.0	21.7
Other On-Site Stations						
23 TA-5	26	5	10.1	0.8	4.2	2.4
25 TA-16-450	26	0	190.3	15.2	68.4	52.7
30 Pajarito Booster 2 (P-2)	26	9	6.8	0.0	2.8	1.8
31 TA-3	26	9	8.1	0.9	3.1	1.6
49 Pajarito Road (TA-36)	26	16	18.5	-1.2	3.0	4.0
QA Stations						
38 TA-54 Area G-QA (next to #27)	26	0	100.8	2.9	33.7	32.3
39 TA-49-QA (next to #26)	26	4	25.2	0.3	5.6	4.7

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (fCi/m ³)	Minimum (fCi/m ³)	Mean (fCi/m ³)	95% Confidence Interval ^b	Sample Standard Deviation
Regional	104	103	5.0	-2.8	-0.1	±0.2	1.0
Pueblo	51	50	13.3	-1.9	0.5	±0.6	2.1
Perimeter	592	225	60.1	-0.8	4.2	±0.4	5.3
TA-15 and TA-36	78	44	6.1	-0.7	2.3	±0.3	1.5
TA-21	52	2	18.9	1.9	7.2	±1.2	4.4
TA-54 Area G	227	4	7316.1	1.2	233.1	±123.6	949.7
Other On-Site	130	39	190.3	-1.2	16.3	±6.1	35.0

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 1,500 pCi/m³.

^aSee Section A.4.a of this chapter and Appendix B for an explanation of negative values.

^b95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-5. Airborne Plutonium-238 Concentrations for 2001

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations						
01 Española	4	4	0.6	-0.6 ^a	0.1	0.5
03 Santa Fe	4	4	0.1	-0.8	-0.3	0.4
55 Santa Fe West (Buckman Booster #4)	4	4	0.4	-0.4	-0.1	0.3
56 El Rancho	4	4	0.5	-0.4	0.1	0.4
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	0.3	-1.0	-0.2	0.6
59 Jemez Pueblo-Visitor's Center	4	4	0.4	-0.3	0.0	0.3
Perimeter Stations						
04 Barranca School	4	4	0.2	-0.6	-0.2	0.3
05 Urban Park	4	4	0.4	-0.6	-0.1	0.4
06 48th Street	4	4	0.0	-0.3	-0.2	0.1
08 McDonald's Restaurant	4	4	0.5	-0.3	0.0	0.4
09 Los Alamos Airport	4	4	0.5	-0.3	0.0	0.4
10 East Gate	4	4	0.3	-0.4	-0.1	0.4
11 Well PM-1 (E. Jemez Road)	4	4	-0.1	-0.5	-0.3	0.2
12 Royal Crest Trailer Court	4	4	0.3	-0.3	0.0	0.3
13 Rocket Park	4	4	0.5	-0.2	0.2	0.3
14 Pajarito Acres	4	4	1.1	-0.7	0.4	0.8
15 White Rock Fire Station	4	4	0.5	-0.2	0.1	0.4
16 White Rock Nazarene Church	4	4	0.2	-0.4	0.0	0.3
17 Bandelier Fire Lookout	4	4	0.1	-0.3	0.0	0.2
26 TA-49	4	4	0.0	-0.4	-0.2	0.1
32 County Landfill	4	4	0.1	-0.3	0.0	0.2
54 TA-33 East	4	4	0.1	-0.4	-0.1	0.2
60 LA Canyon	4	4	0.6	-0.3	0.0	0.4
61 LA Hospital	4	4	0.6	0.0	0.2	0.3
62 Crossroads Bible Church	4	4	0.9	-1.0	-0.1	0.8
63 Monte Rey South	4	4	0.4	-0.3	0.1	0.3
66 Los Alamos Inn-South	4	4	0.8	-0.3	0.3	0.5
67 TA-3 Research Park	4	4	0.3	-0.7	0.0	0.5
68 Airport Road	1	1	0.5	0.5	0.5	
80 Western Arizona Street	2	2	0.1	-0.5	-0.2	0.4
90 East Gate-Backup	2	2	0.3	-0.9	-0.3	0.9
TA-15 and TA-36 Stations						
76 TA-15-41	4	4	0.2	-0.5	-0.2	0.3
77 TA-36 IJ Site	4	4	0.2	-0.8	-0.2	0.5
78 TA-15-N	4	4	0.0	-0.7	-0.4	0.3
TA-21 Stations						
20 TA-21 Area B	4	4	0.3	-0.3	0.1	0.3
71 TA-21.01 (NW Bldg 344)	4	4	0.0	-0.2	-0.1	0.1

Table 4-5. Airborne Plutonium-238 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	4	1.6	-0.5	0.2	1.0
34 Area G-1 (behind trailer)	4	2	9.0	0.1	3.2	4.0
35 Area G-2 (back fence)	4	4	0.0	-0.5	-0.2	0.2
36 Area G-3 (by office)	4	4	0.4	-0.2	0.1	0.3
45 Area G/South East Perimeter	4	4	0.7	0.1	0.4	0.2
47 Area G/North Perimeter	4	4	0.4	-0.6	0.1	0.5
50 Area G-expansion	4	4	0.7	-0.2	0.3	0.4
51 Area G-expansion pit	4	4	1.2	-0.1	0.5	0.6
Other On-Site Stations						
23 TA-5	4	4	0.2	-0.3	-0.1	0.2
25 TA-16-450	4	4	0.0	-0.5	-0.3	0.3
30 Pajarito Booster 2 (P-2)	4	4	1.0	-0.9	0.0	0.8
31 TA-3	4	4	0.9	-0.2	0.2	0.5
49 Pajarito Road (TA-36)	4	4	0.4	-0.5	-0.2	0.4
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	3	2.0	-0.3	0.5	1.1
39 TA-49-QA (next to #26)	4	4	0.1	-0.4	-0.1	0.2

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^b	Sample Standard Deviation
Regional	16	16	0.6	-0.8	0.0	±0.2	0.4
Pueblo	8	8	0.4	-1.0	-0.1	±0.4	0.4
Perimeter	93	93	1.1	-1.0	0.0	±0.1	0.4
TA-15 and TA-36	12	12	0.2	-0.8	-0.2	±0.2	0.3
TA-21	8	8	0.3	-0.3	0.0	±0.2	0.2
TA-54 Area G	32	30	9.0	-0.6	0.6	±0.6	1.7
Other On-Site	20	20	1.0	-0.9	-0.1	±0.2	0.5

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 3,000,000 aCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 2,100 aCi/m³.

^aSee Section A.4.a of this chapter and Appendix B for an explanation of negative values.

^b95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-6. Airborne Plutonium-239 Concentrations for 2001

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations						
01 Española	4	4	1.3	-0.1 ^a	0.5	0.6
03 Santa Fe	4	4	1.0	-0.9	0.3	0.9
55 Santa Fe West (Buckman Booster #4)	4	4	0.2	-0.9	-0.4	0.5
56 El Rancho	4	4	0.8	-0.6	0.1	0.6
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	1.2	0.3	0.6	0.4
59 Jemez Pueblo-Visitor's Center	4	4	0.5	-0.9	-0.2	0.6
Perimeter Stations						
04 Barranca School	4	4	0.9	-0.6	0.2	0.6
05 Urban Park	4	4	1.5	-0.5	0.5	1.0
06 48th Street	4	4	1.2	-0.1	0.5	0.5
08 McDonald's Restaurant	4	3	3.7	-0.3	1.2	1.7
09 Los Alamos Airport	4	3	2.9	-0.3	1.4	1.5
10 East Gate	4	4	0.8	-0.9	-0.1	0.9
11 Well PM-1 (E. Jemez Road)	4	4	1.1	0.0	0.5	0.5
12 Royal Crest Trailer Court	4	4	0.9	-0.7	0.3	0.7
13 Rocket Park	4	3	2.0	0.0	1.3	0.9
14 Pajarito Acres	4	4	1.1	-0.8	0.0	0.9
15 White Rock Fire Station	4	4	0.5	-0.3	0.1	0.3
16 White Rock Nazarene Church	4	4	0.1	-1.0	-0.3	0.5
17 Bandelier Fire Lookout	4	4	0.1	-0.2	-0.1	0.1
26 TA-49	4	4	0.6	-0.5	0.0	0.5
32 County Landfill	4	2	5.5	0.8	2.4	2.1
54 TA-33 East	4	4	0.6	-0.5	0.0	0.4
60 LA Canyon	4	4	1.4	-0.5	0.6	0.8
61 LA Hospital	4	4	1.9	0.4	0.9	0.7
62 Crossroads Bible Church	4	4	2.5	-0.2	0.9	1.1
63 Monte Rey South	4	4	0.3	-0.6	-0.1	0.5
66 Los Alamos Inn-South	4	0	38.6	4.9	19.9	14.0
67 TA-3 Research Park	4	4	1.3	0.6	0.9	0.3
68 Airport Road	1	1	-1.5	-1.5	-1.5	
80 Western Arizona Street	2	2	0.2	0.0	0.1	0.2
90 East Gate-Backup	2	2	2.3	-0.2	1.1	1.7
TA-15 and TA-36 Stations						
76 TA-15-41	4	4	0.8	-0.7	0.1	0.7
77 TA-36 IJ Site	4	4	0.1	-1.2	-0.6	0.6
78 TA-15-N	4	4	1.0	-0.5	-0.1	0.7
TA-21 Stations						
20 TA-21 Area B	4	4	1.3	-0.2	0.2	0.7
71 TA-21.01 (NW Bldg 344)	4	3	25.5	0.7	7.3	12.2

Table 4-6. Airborne Plutonium-239 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	1	14.4	-0.1	5.9	6.2
34 Area G-1 (behind trailer)	4	0	35.6	20.4	25.1	7.0
35 Area G-2 (back fence)	4	4	1.3	-0.5	0.5	0.8
36 Area G-3 (by office)	4	4	1.0	-1.0	0.1	0.9
45 Area G/South East Perimeter	4	1	7.7	1.4	4.0	2.7
47 Area G/North Perimeter	4	2	5.8	0.7	3.3	2.7
50 Area G-expansion	4	3	22.8	0.1	6.5	10.9
51 Area G-expansion pit	4	3	4.1	0.6	1.8	1.6
Other On-Site Stations						
23 TA-5	4	4	0.9	-0.8	0.0	0.9
25 TA-16-450	4	4	1.0	-1.1	0.0	0.9
30 Pajarito Booster 2 (P-2)	4	4	2.0	-0.5	0.4	1.1
31 TA-3	4	4	1.6	-0.3	0.4	0.9
49 Pajarito Road (TA-36)	4	4	0.6	-0.2	0.3	0.4
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	1	9.2	3.0	6.2	2.5
39 TA-49-QA (next to #26)	4	4	1.3	-1.7	0.0	1.3

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^b	Sample Standard Deviation
Regional	16	16	1.3	-0.9	0.1	±0.4	0.7
Pueblo	8	8	1.2	-0.9	0.2	±0.5	0.6
Perimeter	93	84	38.6	-1.5	1.3	±1.0	4.8
TA-15 and TA-36	12	12	1.0	-1.2	-0.2	±0.4	0.7
TA-21	8	7	25.5	-0.2	3.7	±7.4	8.8
TA-54 Area G	32	18	35.6	-1.0	5.9	±3.3	9.0
Other On-Site	20	20	2.0	-1.1	0.2	±0.4	0.8

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 2,000 aCi/m³.

^aSee Section A.4.a of this chapter and Appendix B for an explanation of negative values.

^b95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-7. Airborne Americium-241 Concentrations for 2001

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations						
01 Española	4	4	0.8	-0.7 ^a	-0.1	0.7
03 Santa Fe	4	4	0.5	-1.5	-0.4	1.0
55 Santa Fe West (Buckman Booster #4)	4	4	0.8	-0.7	0.1	0.8
56 El Rancho	4	4	0.8	-1.3	-0.2	1.0
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	1.9	-2.0	0.1	1.6
59 Jemez Pueblo-Visitor's Center	4	4	0.2	-1.4	-0.3	0.7
Perimeter Stations						
04 Barranca School	4	4	1.0	-0.5	0.2	0.8
05 Urban Park	4	4	0.0	-1.0	-0.5	0.4
06 48th Street	4	4	3.9	-1.4	1.0	2.3
08 McDonald's Restaurant	4	4	1.2	-1.3	-0.2	1.1
09 Los Alamos Airport	4	4	1.1	-0.9	0.4	0.9
10 East Gate	4	4	2.7	-1.2	0.5	1.8
11 Well PM-1 (E. Jemez Road)	4	4	1.3	-0.4	0.4	0.9
12 Royal Crest Trailer Court	4	4	2.3	0.6	1.4	0.9
13 Rocket Park	4	4	0.2	-0.6	-0.2	0.4
14 Pajarito Acres	4	4	0.6	-1.2	-0.4	0.8
15 White Rock Fire Station	4	4	-0.2	-1.3	-0.6	0.5
16 White Rock Nazarene Church	4	4	1.0	-0.4	0.2	0.6
17 Bandelier Fire Lookout	4	4	0.5	-0.8	-0.4	0.6
26 TA-49	4	4	3.2	-1.6	0.3	2.0
32 County Landfill	4	4	1.8	-1.0	-0.1	1.3
54 TA-33 East	4	4	2.6	-0.7	0.8	1.4
60 LA Canyon	4	4	2.3	-0.7	0.8	1.2
61 LA Hospital	4	4	0.1	-1.6	-0.7	0.7
62 Crossroads Bible Church	4	4	0.6	-2.0	-0.4	1.1
63 Monte Rey South	4	4	1.4	-1.0	0.0	1.1
66 Los Alamos Inn-South	4	4	0.9	-0.4	0.2	0.5
67 TA-3 Research Park	4	4	0.4	-2.4	-0.6	1.2
68 Airport Road	1	1	5.3	5.3	5.3	
80 Western Arizona Street	2	2	0.2	0.1	0.1	0.1
90 East Gate-Backup	2	2	-1.1	-2.1	-1.6	0.7
TA-15 and TA-36 Stations						
76 TA-15-41	4	4	1.4	-0.9	0.5	1.0
77 TA-36 IJ Site	4	4	0.9	-0.7	0.0	0.7
78 TA-15-N	4	4	0.4	-0.7	0.0	0.5
TA-21 Stations						
20 TA-21 Area B	4	4	0.8	-0.7	0.0	0.6
71 TA-21.01 (NW Bldg 344)	4	4	1.1	-1.7	-0.2	1.2

Table 4-7. Airborne Americium-241 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	2	11.2	0.1	4.1	5.1
34 Area G-1 (behind trailer)	4	0	105.3	33.7	66.6	29.4
35 Area G-2 (back fence)	4	4	0.5	-1.3	-0.7	0.8
36 Area G-3 (by office)	4	4	1.1	-1.7	-0.2	1.4
45 Area G/South East Perimeter	4	3	2.9	-0.3	1.7	1.5
47 Area G/North Perimeter	4	1	12.3	2.8	7.8	4.1
50 Area G-expansion	4	4	2.8	-0.4	1.3	1.4
51 Area G-expansion pit	4	4	1.5	-0.5	0.3	0.9
Other On-Site Stations						
23 TA-5	4	4	1.5	-1.8	-0.7	1.5
25 TA-16-450	4	4	1.2	-1.0	0.2	0.9
30 Pajarito Booster 2 (P-2)	4	4	1.0	-1.2	-0.2	1.0
31 TA-3	4	4	1.1	-1.5	-0.1	1.1
49 Pajarito Road (TA-36)	4	4	0.6	-1.5	-0.7	1.0
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	2	7.3	0.3	3.8	3.2
39 TA-49-QA (next to #26)	4	4	-0.1	-1.2	-0.8	0.5

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^b	Sample Standard Deviation
Regional	16	16	0.8	-1.5	-0.2	±0.4	0.8
Pueblo	8	8	1.9	-2.0	-0.1	±1.0	1.2
Perimeter	93	93	5.3	-2.4	0.1	±0.3	1.3
TA-15 and TA-36	12	12	1.4	-0.9	0.2	±0.5	0.7
TA-21	8	8	1.1	-1.7	-0.1	±0.8	0.9
TA-54 Area G	32	22	105.3	-1.7	10.1	±8.6	23.8
Other On-Site	20	20	1.5	-1.8	-0.3	±0.5	1.0

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 1,900 aCi/m³.

^aSee Section A.4.a of this chapter and Appendix B for an explanation of negative values.

^b95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-8. Airborne Uranium-234 Concentrations for 2001

Station Location		Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations							
01	Española	4	0	29.5	10.0	18.6	8.2
03	Santa Fe	4	0	61.3	10.4	27.6	23.2
55	Santa Fe West (Buckman Booster #4)	4	0	14.0	5.9	10.0	3.3
56	El Rancho	4	0	22.6	4.6	15.3	8.2
Pueblo Stations							
41	San Ildefonso Pueblo	4	0	36.3	10.2	23.8	12.3
59	Jemez Pueblo-Visitor's Center	4	0	40.7	20.9	31.8	9.4
Perimeter Stations							
04	Barranca School	4	0	20.7	6.5	14.0	6.9
05	Urban Park	4	0	22.3	7.7	12.8	6.5
06	48th Street	4	2	9.6	2.1	5.8	4.0
08	McDonald's Restaurant	4	0	17.5	5.1	9.9	5.4
09	Los Alamos Airport	4	0	9.6	5.8	8.2	1.7
10	East Gate	4	0	12.7	3.8	7.9	3.7
11	Well PM-1 (E. Jemez Road)	4	3	10.2	2.1	4.4	3.9
12	Royal Crest Trailer Court	4	0	23.5	5.5	10.6	8.7
13	Rocket Park	4	0	9.7	5.6	7.5	1.9
14	Pajarito Acres	4	0	11.3	5.3	7.0	2.9
15	White Rock Fire Station	4	0	17.0	9.4	11.9	3.4
16	White Rock Nazarene Church	4	0	9.4	4.5	5.8	2.4
17	Bandelier Fire Lookout	4	1	9.3	1.7	5.2	3.1
26	TA-49	4	1	9.4	1.6	6.0	3.3
32	County Landfill	4	0	73.1	36.7	51.4	16.3
54	TA-33 East	4	0	11.8	3.1	6.8	3.7
60	LA Canyon	4	0	17.4	3.8	10.3	6.0
61	LA Hospital	4	0	14.9	6.8	11.4	3.5
62	Crossroads Bible Church	4	0	11.9	6.1	8.7	3.0
63	Monte Rey South	4	0	8.7	4.8	7.1	1.7
66	Los Alamos Inn-South	4	0	23.9	4.9	10.3	9.1
67	TA-3 Research Park	4	0	29.9	10.7	19.9	10.1
68	Airport Road	1	1	5.1	5.1	5.1	
80	Western Arizona Street	2	0	14.1	8.5	11.3	3.9
90	East Gate-Backup	2	1	6.8	5.9	6.4	0.6
TA-15 and TA-36 Stations							
76	TA-15-41	4	0	14.6	2.9	7.3	5.1
77	TA-36 IJ Site	4	0	61.9	11.1	24.2	25.2
78	TA-15-N	4	0	12.0	4.1	6.9	3.7
TA-21 Stations							
20	TA-21 Area B	4	0	14.0	6.0	10.1	3.7
71	TA-21.01 (NW Bldg 344)	4	0	13.2	4.9	8.2	3.7

4. Air Surveillance

Table 4-8. Airborne Uranium-234 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	0	58.6	9.5	21.9	24.5
34 Area G-1 (behind trailer)	4	0	72.8	21.5	46.6	22.3
35 Area G-2 (back fence)	4	0	29.0	6.1	14.2	10.1
36 Area G-3 (by office)	4	1	25.8	2.9	10.6	10.3
45 Area G/South East Perimeter	4	0	88.3	18.5	48.0	33.2
47 Area G/North Perimeter	4	0	25.7	9.5	15.0	7.5
50 Area G-expansion	4	0	68.2	20.3	33.5	23.2
51 Area G-expansion pit	4	0	63.9	9.2	26.2	25.3
Other On-Site Stations						
23 TA-5	4	0	15.8	5.6	10.5	4.2
25 TA-16-450	4	0	15.0	5.4	8.9	4.4
30 Pajarito Booster 2 (P-2)	4	0	18.4	8.9	12.7	4.2
31 TA-3	4	0	20.8	8.5	12.6	5.6
49 Pajarito Road (TA-36)	4	0	16.8	6.7	9.8	4.7
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	0	47.9	11.4	21.3	17.8
39 TA-49-QA (next to #26)	4	1	18.3	3.7	8.5	6.7

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^a	Sample Standard Deviation
Regional	16	0	61.3	4.6	17.9	±7.2	13.4
Pueblo	8	0	40.7	10.2	27.8	±9.2	11.0
Perimeter	93	9	73.1	1.6	10.9	±2.2	10.6
TA-15 and TA-36	12	0	61.9	2.9	12.8	±10.1	15.9
TA-21	8	0	14.0	4.9	9.2	±3.0	3.6
TA-54 Area G	32	1	88.3	2.9	27.0	±8.4	23.3
Other On-Site	20	0	20.8	5.4	10.9	±2.1	4.4

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 7,700 aCi/m³.

^a95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-9. Airborne Uranium-235 Concentrations for 2001

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations						
01 Española	4	3	4.1	-0.1 ^a	1.6	1.8
03 Santa Fe	4	2	6.7	0.3	2.9	3.1
55 Santa Fe West Buckman Booster #4)	4	4	1.4	-0.5	0.6	1.0
56 El Rancho	4	4	2.1	-0.7	0.1	1.3
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	2.3	0.3	1.5	0.9
59 Jemez Pueblo-Visitor's Center	4	3	3.4	-0.1	1.8	1.4
Perimeter Stations						
04 Barranca School	4	4	0.9	0.0	0.5	0.4
05 Urban Park	4	4	1.7	-1.1	0.2	1.2
06 48th Street	4	4	2.5	-0.5	0.5	1.3
08 McDonald's Restaurant	4	4	2.6	-0.7	0.5	1.5
09 Los Alamos Airport	4	4	1.3	-0.6	0.3	0.8
10 East Gate	4	4	1.2	0.3	0.8	0.5
11 Well PM-1 (E. Jemez Road)	4	4	2.8	-0.9	1.2	1.6
12 Royal Crest Trailer Court	4	4	0.1	-0.3	-0.1	0.2
13 Rocket Park	4	4	1.6	-1.0	0.5	1.1
14 Pajarito Acres	4	4	1.3	0.3	0.7	0.5
15 White Rock Fire Station	4	4	1.4	0.7	1.0	0.3
16 White Rock Nazarene Church	4	4	1.2	-1.6	0.1	1.2
17 Bandelier Fire Lookout	4	4	-0.2	-1.8	-0.9	0.7
26 TA-49	4	4	0.6	-1.1	-0.1	0.7
32 County Landfill	4	3	4.4	0.9	2.2	1.5
54 TA-33 East	4	4	2.4	-0.2	1.0	1.1
60 LA Canyon	4	4	1.0	-2.1	-0.1	1.4
61 LA Hospital	4	4	1.4	-0.2	0.5	0.7
62 Crossroads Bible Church	4	4	1.4	-0.1	0.6	0.7
63 Monte Rey South	4	3	3.2	0.0	0.9	1.5
66 Los Alamos Inn-South	4	4	1.6	-0.7	0.2	1.0
67 TA-3 Research Park	4	4	1.3	-0.6	0.6	0.9
68 Airport Road	1	1	4.9	4.9	4.9	
80 Western Arizona Street	2	2	1.8	-0.1	0.8	1.3
90 East Gate-Backup	2	2	1.4	-3.5	-1.0	3.5
TA-15 and TA-36 Stations						
76 TA-15-41	4	4	0.8	-0.9	0.1	0.8
77 TA-36 IJ Site	4	3	6.2	1.5	3.0	2.2
78 TA-15-N	4	4	0.0	-0.7	-0.3	0.3
TA-21 Stations						
20 TA-21 Area B	4	4	1.3	-1.1	0.0	1.2
71 TA-21.01 (NW Bldg 344)	4	4	1.1	0.0	0.6	0.5

Table 4-9. Airborne Uranium-235 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	3	5.1	0.2	1.5	2.4
34 Area G-1 (behind trailer)	4	2	4.9	-0.1	2.6	2.4
35 Area G-2 (back fence)	4	4	1.1	-0.1	0.7	0.5
36 Area G-3 (by office)	4	4	1.4	-0.8	0.2	1.1
45 Area G/South East Perimeter	4	2	6.4	0.2	3.1	2.6
47 Area G/North Perimeter	4	4	1.1	-0.6	0.3	0.9
50 Area G-expansion	4	4	2.1	-0.1	0.9	1.0
51 Area G-expansion pit	4	2	3.7	2.0	2.8	0.7
Other On-Site Stations						
23 TA-5	4	4	1.6	0.1	0.5	0.7
25 TA-16-450	4	4	0.5	-1.3	-0.5	0.8
30 Pajarito Booster 2 (P-2)	4	3	4.5	1.0	2.4	1.5
31 TA-3	4	4	2.0	0.7	1.5	0.6
49 Pajarito Road (TA-36)	4	3	2.9	0.4	1.6	1.3
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	4	1.6	0.2	0.8	0.6
39 TA-49-QA (next to #26)	4	4	2.0	-0.3	0.9	1.0

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^b	Sample Standard Deviation
Regional	16	13	6.7	-0.7	1.3	±1.1	2.1
Pueblo	8	7	3.4	-0.1	1.6	±0.9	1.1
Perimeter	93	91	4.9	-3.5	0.5	±0.3	1.2
TA-15 and TA-36	12	11	6.2	-0.9	0.9	±1.2	2.0
TA-21	8	8	1.3	-1.1	0.3	±0.7	0.9
TA-54 Area G	32	25	6.4	-0.8	1.5	±0.7	1.8
Other On-Site	20	18	4.5	-1.3	1.1	±0.6	1.4

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m³. See Appendix A.
EPA 40 CFR 61 Concentration Guide 7,100 aCi/m³.

^aSee Section A.4.a of this chapter and Appendix B for an explanation of negative values.

^b95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-10. Airborne Uranium-238 Concentrations for 2001

Station Location		Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
Regional Stations							
01	Española	4	0	39.7	11.2	21.9	13.5
03	Santa Fe	4	0	55.7	9.4	25.7	20.6
55	Santa Fe West (Buckman Booster #4)	4	1	13.8	1.7	7.4	5.4
56	El Rancho	4	0	26.1	6.6	15.7	8.9
Pueblo Stations							
41	San Ildefonso Pueblo	4	0	37.9	10.6	23.6	11.6
59	Jemez Pueblo-Visitor's Center	4	0	46.7	22.7	31.2	11.0
Perimeter Stations							
04	Barranca School	4	0	22.4	3.9	16.4	8.5
05	Urban Park	4	0	24.2	6.5	12.4	8.1
06	48th Street	4	1	5.6	2.2	3.6	1.4
08	McDonald's Restaurant	4	0	17.6	4.5	9.7	5.9
09	Los Alamos Airport	4	0	19.6	7.0	13.3	5.6
10	East Gate	4	0	23.6	5.6	11.1	8.4
11	Well PM-1 (E. Jemez Road)	4	1	9.1	3.2	5.9	2.9
12	Royal Crest Trailer Court	4	1	28.6	3.4	12.4	11.2
13	Rocket Park	4	0	11.9	3.8	8.4	3.5
14	Pajarito Acres	4	0	20.8	4.4	11.1	6.9
15	White Rock Fire Station	4	0	26.8	11.0	15.7	7.4
16	White Rock Nazarene Church	4	0	8.1	3.8	6.7	2.0
17	Bandelier Fire Lookout	4	2	13.9	2.5	7.5	5.7
26	TA-49	4	0	16.0	3.0	9.4	5.6
32	County Landfill	4	0	75.7	37.2	54.0	16.6
54	TA-33 East	4	1	8.5	3.5	6.3	2.1
60	LA Canyon	4	0	15.7	4.2	10.3	6.2
61	LA Hospital	4	0	11.5	6.4	8.2	2.3
62	Crossroads Bible Church	4	0	20.5	11.5	16.9	4.0
63	Monte Rey South	4	0	22.1	7.5	12.8	6.5
66	Los Alamos Inn-South	4	0	25.1	7.5	12.1	8.6
67	TA-3 Research Park	4	0	30.7	8.7	19.8	10.9
68	Airport Road	1	1	1.8	1.8	1.8	
80	Western Arizona Street	2	0	13.0	6.5	9.7	4.6
90	East Gate-Backup	2	0	13.5	4.7	9.1	6.2
TA-15 and TA-36 Stations							
76	TA-15-41	4	0	22.9	4.7	14.8	7.5
77	TA-36 IJ Site	4	0	377.5	31.5	125.4	168.4
78	TA-15-N	4	0	21.7	5.5	16.0	7.2
TA-21 Stations							
20	TA-21 Area B	4	0	34.8	6.8	18.1	12.0
71	TA-21.01 (NW Bldg 344)	4	0	24.5	4.5	14.5	8.1

Table 4-10. Airborne Uranium-238 Concentrations for 2001 (Cont.)

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	0	63.4	11.0	25.1	25.6
34 Area G-1 (behind trailer)	4	0	71.9	28.4	48.5	20.5
35 Area G-2 (back fence)	4	0	42.8	8.6	20.7	15.2
36 Area G-3 (by office)	4	0	39.0	6.4	16.4	15.3
45 Area G/South East Perimeter	4	0	97.2	23.7	50.7	34.8
47 Area G/North Perimeter	4	0	39.0	8.2	18.3	14.1
50 Area G-expansion	4	0	64.5	19.2	34.4	20.5
51 Area G-expansion pit	4	0	82.3	12.5	30.7	34.4
Other On-Site Stations						
23 TA-5	4	0	33.7	16.3	22.7	7.6
25 TA-16-450	4	0	15.7	6.0	10.3	4.3
30 Pajarito Booster 2 (P-2)	4	0	32.9	8.3	17.2	11.4
31 TA-3	4	0	20.7	9.5	12.7	5.3
49 Pajarito Road (TA-36)	4	0	35.3	4.1	18.2	14.6
QA Stations						
38 TA-54 Area G-QA (next to #27)	4	0	53.1	12.8	25.8	18.4
39 TA-49-QA (next to #26)	4	0	17.1	4.7	10.1	6.2

Group Summaries

Station Location	Number of Measurements	Number of Measurements <Uncertainty	Maximum (aCi/m ³)	Minimum (aCi/m ³)	Mean (aCi/m ³)	95% Confidence Interval ^a	Sample Standard Deviation
Regional	16	1	55.7	1.7	17.7	±7.4	13.9
Pueblo	8	0	46.7	10.6	27.4	±9.4	11.2
Perimeter	93	7	75.7	1.8	12.6	±2.4	11.5
TA-15 and TA-36	12	0	377.5	4.7	52.1	±65.7	103.4
TA-21	8	0	34.8	4.5	16.3	±8.1	9.7
TA-54 Area G	32	0	97.2	6.4	30.6	±8.8	24.5
Other On-Site	20	0	35.3	4.1	16.2	±4.5	9.5

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m³. See Appendix A.

EPA 40 CFR 61 Concentration Guide 8,300 aCi/m³.

^a95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

4. Air Surveillance

Table 4-11. Airborne Gamma-Emitting Radionuclides that are Potentially Released by LANL Operations

Gamma Emitting Radionuclide	Number of Measurements	Number of Measurements \leq MDA	Mean (fCi/m ³)	Measured Average MDA as a Percent of the Required MDA
⁷³ As	300	300	$\ll 1.31$	0.2
⁷⁴ As	300	300	$\ll 0.64$	0.6
¹⁰⁹ Cd	300	300	$\ll 0.22$	0.7
⁵⁷ Co	300	300	$\ll 0.19$	0.3
⁶⁰ Co	300	300	$\ll 0.33$	39.0
¹³⁴ Cs	300	300	$\ll 0.30$	22.4
¹³⁷ Cs	300	300	$\ll 0.29$	30.0
⁵⁴ Mn	300	300	$\ll 0.33$	2.4
²² Na	300	300	$\ll 0.34$	26.1
⁸³ Rb	300	300	$\ll 0.65$	3.8
⁸⁶ Rb	300	300	$\ll 4.76$	17.0
¹⁰³ Ru	300	300	$\ll 0.32$	0.2
⁷⁵ Se	300	300	$\ll 0.30$	3.5
⁶⁵ Zn	300	300	$\ll 0.68$	14.9

Table 4-12. Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities

Gamma Emitting Radionuclide	Number of Measurements	Number of Measurements $<$ MDA	Mean ^a (fCi/m ³)
⁷ Be	300	0	59
²¹⁰ Pb	286	14	10

^aMeasurements that are less than the MDA are not included in the Mean because they are “less than” values.

Table 4-13. Airborne Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 2001 (Ci)

TA-Building	$^3\text{H}^{\text{a}}$	^{241}Am	Pu^{b}	U^{c}	Th	P/VAP ^d	G/MAP ^e
TA-03-029		2.6×10^{-7}	9.2×10^{-6}	7.1×10^{-6}	1.4×10^{-7}		
TA-03-102				2.2×10^{-8}			
TA-16-205	7.9×10^3						
TA-21-155	6.6×10^1						
TA-21-209	4.2×10^2						
TA-33-086	4.6×10^2						
TA-41-004	5.3×10^2						
TA-48-001						2.3×10^{-3}	
TA-50-001			4.3×10^{-8}				
TA-50-037 ^f							
TA-50-069		5.8×10^{-11}	3.1×10^{-10}				
TA-53-003	6.7×10^{-1}						2.0×10^0
TA-53-007	5.7×10^0					1.1×10^0	5.9×10^3
TA-55-004	3.3×10^0	6.2×10^{-9}	4.3×10^{-8}	1.7×10^{-7}	1.5×10^{-7}		
Total^g	9.4×10^3	2.7×10^{-7}	9.3×10^{-6}	7.3×10^{-6}	2.9×10^{-7}	1.1×10^0	$6.1 \times 10^{3\text{h}}$

^aIncludes both gaseous and oxide forms of tritium.^bIncludes ^{238}Pu , ^{239}Pu , and ^{240}Pu .^cIncludes ^{234}U , ^{235}U , and ^{238}U .^dP/VAP—Particulate/vapor activation products.^eG/MAP—Gaseous/mixed activation products.^fNo emissions detected.^gSome differences may occur because of rounding.^hTotal for G/MAP includes 156 curies released from diffuse sources at TA-53.

4. Air Surveillance

Table 4-14. Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 2001 (Ci)

TA-Building	Radionuclide	Emission
TA-48-001	⁷³ As	4.2×10^{-5}
TA-48-001	⁷⁴ As	1.1×10^{-5}
TA-48-001	⁶⁸ Ga	1.2×10^{-3}
TA-48-001	⁶⁸ Ge	1.2×10^{-3}
TA-53-003	¹¹ C	2.0×10^0
TA-53-007	⁴¹ Ar	1.6×10^1
TA-53-007	⁷³ As	2.2×10^{-5}
TA-53-007	⁷⁶ Br	2.6×10^{-4}
TA-53-007	⁸² Br	4.2×10^{-3}
TA-53-007	¹⁰ C	2.5×10^0
TA-53-007	¹¹ C	3.4×10^3
TA-53-007	¹⁹³ Hg	8.0×10^{-1}
TA-53-007	^{195m} Hg	2.0×10^{-2}
TA-53-007	¹⁹⁷ Hg	1.0×10^{-1}
TA-53-007	¹³ N	1.3×10^2
TA-53-007	¹⁶ N	2.8×10^{-2}
TA-53-007	¹⁴ O	3.4×10^1
TA-53-007	¹⁵ O	2.4×10^3

Table 4-15. Radionuclide: Half-Life Information

Nuclide	Half-Life
³ H	12.3 yr
⁷ Be	53.4 d
¹⁰ C	19.3 s
¹¹ C	20.5 min
¹³ N	10.0 min
¹⁶ N	7.13 s
¹⁴ O	70.6 s
¹⁵ O	122.2 s
²² Na	2.6 yr
²⁴ Na	14.96 h
³² P	14.3 d
⁴⁰ K	1,277,000,000 yr
⁴¹ Ar	1.83 h
⁵⁴ Mn	312.7 d
⁵⁶ Co	78.8 d
⁵⁷ Co	270.9 d
⁵⁸ Co	70.8 d
⁶⁰ Co	5.3 yr
⁷² As	26 h
⁷³ As	80.3 d
⁷⁴ As	17.78 d
⁷⁶ Br	16 h
⁷⁷ Br	2.4 d
⁸² Br	1.47 d
⁷⁵ Se	119.8 d
⁸⁵ Sr	64.8 d
⁸⁹ Sr	50.6 d
⁹⁰ Sr	28.6 yr
¹³¹ I	8 d
¹³⁴ Cs	2.06 yr
¹³⁷ Cs	30.2 yr
¹⁸³ Os	13 h
¹⁸⁵ Os	93.6 d
¹⁹¹ Os	15.4 d
¹⁹³ Hg	3.8 hr
¹⁹⁵ Hg	9.5 hr
^{195m} Hg	1.67 d
¹⁹⁷ Hg	2.67 d
^{197m} Hg	23.8 hr
²³⁴ U	244,500 yr
²³⁵ U	703,800,000 yr
²³⁸ U	4,468,000,000 yr
²³⁸ Pu	87.7 yr
²³⁹ Pu	24,131 yr
²⁴⁰ Pu	6,569 yr
²⁴¹ Pu	14.4 yr
²⁴¹ Am	432 yr

Table 4-16. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 2000–2001

TLD Station ID #	Location	2000 Annual Dose (mrem)	2001 Quarters Monitored	2001 Annual Dose (mrem)
01	NNMCC, Española	108 ± 8	1,2	107 ± 8
05	Barranca School, Los Alamos	141 ± 10	1,2	127 ± 9
08	48th Street, Los Alamos	152 ± 11	1–4	142 ± 10
09	Los Alamos Airport	124 ± 9	1–4	122 ± 9
12	Royal Crest Trailer Court, Los Alamos	138 ± 10	1–4	133 ± 9
13	White Rock Fire Station	135 ± 9	1–4	129 ± 9
15	Bandelier National Monument	144 ± 10	1–4	143 ± 10
17	TA-21 (DP West)	150 ± 11	1–4	149 ± 10
18	TA-6 Entrance Station	134 ± 9	1–4	132 ± 9
19	TA-53 (LANSCE) West	155 ± 11	1–4	145 ± 10
20	TA-72 Well PM-1, SR 4 and Truck Rt.	165 ± 12	1–4	153 ± 11
21	TA-16 (S-Site) Rt. 501	143 ± 10	1–4	134 ± 9
22	TA-54 West, Booster P-2	145 ± 10	1–4	136 ± 10
23	TA-3 East Gate of SM 43	123 ± 9	1–4	110 ± 8
25	TA-49 (Frijoles Mesa)	131 ± 9	1–4	126 ± 9
28	TA-18 (Pajarito Site)	180 ± 13	1–4	179 ± 13
29	TA-35 (Ten Site A)	126 ± 9	1–4	122 ± 9
30	TA-35 (Ten Site B)	114 ± 8	1–4	110 ± 8
37	TA-72 (Pistol Range)	160 ± 11	1–4	156 ± 11
38	TA-55 (Plutonium Facility South)	150 ± 11	1–4	142 ± 10
39	TA-55 (Plutonium Facility West)	155 ± 11	1–4	150 ± 11
41	McDonald's Restaurant, Los Alamos	138 ± 10	1–4	140 ± 10
47	Urban Park, Los Alamos	141 ± 10	1–4	134 ± 9
48	TA-61 Los Alamos County Landfill	132 ± 9	1–4	122 ± 9
49	Piñon School (Rocket Park) White Rock	127 ± 9	1–4	123 ± 9
50	White Rock Church of the Nazarene	124 ± 9	1–4	117 ± 8
53	San Ildefonso Pueblo	125 ± 9	1–4	109 ± 8
55	Monte Rey South, White Rock	122 ± 9	1–4	117 ± 8
58	TA-36 Pajarito Road (South of TA-54)	154 ± 11	1–4	148 ± 10
59	TA-43 Los Alamos Canyon	162 ± 11	1–4	155 ± 11
60	Piedra Drive, White Rock	122 ± 9	1–4	114 ± 8
64	TA-53 NE LANSCE Area A Stack	201 ± 8	1–4	181 ± 13
65	TA-53 NW LANSCE Area A Stack	160 ± 11	1–4	155 ± 11
66	TA-73 East Gate	150 ± 11	1–4	147 ± 10
67	Los Alamos Medical Center	134 ± 9	1–4	132 ± 9
68	Trinity (Crossroads) Bible Church	140 ± 10	1–4	126 ± 9
69	TA-50 Old Outfall	166 ± 12	1–4	159 ± 11
70	TA-50 Dirt Road to Outfall	170 ± 12	1–4	163 ± 11
71	TA-50 Dirt Road Turnoff	150 ± 11	1–4	149 ± 10
72	TA-50 East Fence, S. Corner	148 ± 10	1–4	142 ± 10
73	TA-50 East Fence, N. Corner	125 ± 9	1–4	119 ± 8
74	TA-50 Pecos Drive	126 ± 9	1–4	120 ± 8
75	TA-50-37 West	140 ± 10	1–4	131 ± 9
76	TA-16-450 WETF	136 ± 10	1–4	127 ± 9
77	TA-16-210 Guard Station	144 ± 10	1,3,4	133 ± 9
78	TA-8-24 Fitness Trail SW	140 ± 10	1–4	133 ± 9
79	TA-8-24 Fitness Trail SE	144 ± 10	1–4	140 ± 10
80	TA-16 SR 4 Back Gate	133 ± 9	1–4	133 ± 9
81	TA-16 SR 4 Ponderosa Camp	134 ± 9	1,2	121 ± 8
82	TA-15 Phermex N TA-15-185	163 ± 11	1–4	158 ± 11
83	TA-15 Phermex Entrance	130 ± 9	2–4	124 ± 9

4. Air Surveillance

Table 4-16. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 2000–2001 (Cont.)

TLD Station ID #	Location	2000 Annual Dose (mrem)	2001 Quarters Monitored	2001 Annual Dose (mrem)
84	TA-15 Phermex NNE Entrance	134 ± 9	1–4	131 ± 9
85	TA-15 Phermex N DAHRT	135 ± 9	1–4	132 ± 9
86	TA-15-312 DAHRT Entrance	144 ± 10	1–4	136 ± 10
87	TA-15-183 Access Control	143 ± 10	1–4	144 ± 10
88	TA-15 R-Site Road	143 ± 10	1–4	136 ± 10
89	TA-15-45 SW	157 ± 11	1–4	145 ± 10
90	TA-15-306 North	151 ± 11	1–4	133 ± 9
91	TA-15, IJ Firing Point	142 ± 10	1–4	132 ± 9
92	TA-36 Kappa Site	153 ± 11	1–4	128 ± 9
93	TA-15 Ridge Road Gate	134 ± 9	1–4	129 ± 9
94	TA-33 East (VLBA Dish)	120 ± 8	1–4	114 ± 8
95	El Rancho	126 ± 9	1–4	115 ± 8
100	TA-5 Mortandad Canyon, MCO-13	143 ± 10	1–4	146 ± 10
101	Santa Fe West	117 ± 8	1–4	112 ± 8
103	Santa Clara Pueblo	162 ± 11	1–4	137 ± 10
104	TA-53 NE LANSCE Lagoons	198 ± 14	1–4	156 ± 11
105	TA-3 Wellness Center	122 ± 9	1–3	116 ± 8
106	TA-3 University House	127 ± 9	1–4	120 ± 8
107	TA-5 AIRNET	120 ± 8	1–4	118 ± 8
108	TA-43 HRL	130 ± 9	1–4	125 ± 9
109	TA-48 South	130 ± 9	1–4	131 ± 9
110	TA-21 AIRNET	131 ± 9	1–4	129 ± 9
114	TA-53 E of LANSCE Lagoons	163 ± 11	1–4	145 ± 10
115	TA-53 N of LANSCE Lagoons	181 ± 13	1–4	160 ± 11
116	TA-53 Old LANSCE Lagoons	355 ± 25	1–4	207 ± 14
117	TA-3-130 Calibration Lab	224 ± 16	1–4	172 ± 12
118	TA-3-130 inside east fence	NA ^a	1–4	474 ± 33
119	TA-3-130 inside south fence	NA ^a	1–4	679 ± 48
120	TA-2 Omega West	NA ^a	1–4	146 ± 10
121	Los Alamos Inn	NA ^a	1–4	144 ± 10
122	TA-3 Research Park	NA ^a	1–4	123 ± 9
228	TA-49 AB-8	136 ± 10	1–4	127 ± 9
229	TA-49 AB-9	137 ± 10	1–4	123 ± 9
230	TA-49 AB-10	140 ± 10	1–4	135 ± 9
254	TA-21 Area B-14	142 ± 10	1–4	143 ± 10
261	TA-50 NW Area C	125 ± 9	1–4	122 ± 9
262	TA-50 N Area C	144 ± 10	1–4	140 ± 10
265	TA-50 SE Area C	141 ± 10	1–4	139 ± 10
267	TA-50 S Area C	144 ± 10	1–4	136 ± 10
268	TA-50 SW Area C	137 ± 10	1–4	127 ± 9
269	TA-50 SW Area C	142 ± 10	1–4	132 ± 9
270	TA-50 W Area C	140 ± 10	1–4	140 ± 10
323	TA-21 Area T	278 ± 19	1–4	265 ± 19
361	TA-21 Area V	140 ± 10	1–4	127 ± 9
401	TA-73 NE of LANSCE	148 ± 10	1–4	145 ± 10
403	TA-73 NNE of LANSCE	152 ± 11	1–4	150 ± 10
405	TA-73 N of LANSCE	151 ± 11	1–4	150 ± 10
408	TA-73 NNW of LANSCE	160 ± 11	1–4	156 ± 11
412	TA-73 NW of LANSCE	148 ± 10	1–4	153 ± 11

^aNA = Not applicable; there were no 2001 data at this location.

Table 4-17. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at the Waste Disposal Area G during 2000–2001

TLD Station ID #	Location	2000 Annual Dose (mrem)	2001 Quarters Monitored	2001 Annual Dose (mrem)
601	TA-54 Area G, 1	170 ± 12	1–4	165 ± 12
602	TA-54 Area G, 2	269 ± 19	1–4	263 ± 18
603	TA-54 Area G, 3	165 ± 12	1–4	167 ± 12
604	TA-54 Area G, 4	169 ± 12	1–4	176 ± 12
605	TA-54 Area G, 5	253 ± 18	1–4	295 ± 21
606	TA-54 Area G, 6	835 ± 60	1–4	952 ± 67
607	TA-54 Area G, 7	212 ± 15	1–4	241 ± 17
608	TA-54 Area G, 8	180 ± 13	1–4	186 ± 13
610	TA-54 Area G, 10	202 ± 14	1–4	205 ± 14
611	TA-54 Area G, 11	489 ± 34	1–4	466 ± 33
613	TA-54 Area G, 13	352 ± 25	1–4	346 ± 24
614	TA-54 Area G, 14	273 ± 19	1–4	272 ± 19
615	TA-54 Area G, 15	174 ± 12	1–4	177 ± 12
616	TA-54 Area G, 16	193 ± 14	1–4	203 ± 14
617	TA-54 Area G, 17	170 ± 12	1–4	167 ± 12
618	TA-54 Area G, 18	170 ± 12	1–4	175 ± 12
619	TA-54 Area G, 19	225 ± 16	1–4	220 ± 15
620	TA-54 Area G, 20	167 ± 12	1–4	160 ± 11
622	TA-54 Area G, 22	227 ± 16	1–4	226 ± 16
623	TA-54 Area G, 23	254 ± 18	1–4	295 ± 21
624	TA-54 Area G, 24	457 ± 32	1–4	372 ± 26
625	TA-54 Area G, 25	196 ± 14	1–4	188 ± 13
626	TA-54 Area G, 26	164 ± 11	1–4	157 ± 11
627	TA-54 Area G, 27	237 ± 17	1–4	246 ± 17
628	TA-54 Area G, 28	232 ± 16	1–4	251 ± 18
629	TA-54 Area G, 29	195 ± 14	1–4	199 ± 14
630	TA-54 Area G, 30	248 ± 17	1–4	230 ± 16
631	TA-54 Area G, 31	180 ± 13	1–4	182 ± 13
634	TA-54 Area G, 34	212 ± 15	1–4	220 ± 15
635	TA-54 Area G, 35	238 ± 17	1–4	229 ± 16
636	TA-54 Area G, 36	162 ± 11	1–4	160 ± 11
637	TA-54 Area G, 37	164 ± 11	1–4	169 ± 12
638	TA-54 Area G, 38	154 ± 11	1–4	153 ± 11
639	TA-54 Area G, 39	225 ± 16	1–4	231 ± 16
640	TA-54 Area G, 40	268 ± 19	1–4	247 ± 17
641	TA-54 Area G, 41	276 ± 19	1–4	263 ± 18
642	TA-54 Area G, 42	190 ± 13	1–4	195 ± 14
643	TA-54 Area G, 43	205 ± 14	1–4	205 ± 14

4. Air Surveillance

Table 4-18. Albedo Dosimeter Network

Location ID#	Location	Neutron Dose (mrem)
1	NEWNET Kappa Site	16.4
2	TA-36 Entrance	10.3
3	TA-18 Personnel Gate at Parking Lot	65.8
4	P2 Booster Station at TA-54 Entrance	2.3
5	TA-51 Entrance	1.7
6	Pajarito Hill West of TA-18 Entrance	13.4
7	TA-18 Entrance at Pajarito Road	26.6
8	TA-49 Background	1.4
9	Santa Fe Background	2.1
10	TA-3-130 Calibration Lab North	57.7
11	TA-3-130 Calibration Lab East	380.0
12	TA-3-130 Calibration Lab South	439.4

Table 4-19. Airborne Inorganic Element Concentrations for 2001

Station Location	Analysis	Number of Measurements	Number of Measurements <Detection Limit	Range (ng/m ³)	Mean (ng/m ³)	Standard Deviation of Mean (ng/m ³)
Los Alamos						
81 Intersection of Diamond and E. Jemez	Ag	18		-0.09-0.29	0.10	0.09
	As	9		0.013-0.57	0.24	0.15
	Ba	18		7.1-39	20	11
	Be	9		0.02-0.10	0.05	0.03
	Cd	18	2	-0.03-0.24	0.09	0.06
	Co	18		0.09-0.55	0.28	0.16
	Cr	18		0.51-3.9	1.9	1.1
	Cu	18		18-65	39	14
	Ni	18		0.67-3.5	1.5	0.9
	Pb	18		1.5-7.3	3.1	1.6
	Sb	18		0.29-1.24	0.58	0.27
	Se	9	3	0.12-0.38	0.21	0.10
	Tl	18	10	0.004-0.08	0.02	0.02
	V	9		0.59-2.85	1.7	0.8
	Zn	18		11-41	24	11
61 LA Hospital	Ag	16		0.02-0.91	0.15	0.21
	As	8		-0.009-0.32	0.19	0.10
	Ba	16		4.3-24.7	11.7	6.2
	Be	8	1	0.015-0.10	0.042	0.028
	Cd	16		-0.012-0.17	0.090	0.055
	Co	16		0.05-0.32	0.16	0.07
	Cr	16		0.5-3.4	1.6	1.1
	Cu	16		16-47	31	9
	Ni	16		0.2-1.9	1.0	0.6
	Pb	16		1.0-4.6	2.8	1.2
	Sb	16		0.15-0.79	0.49	0.21
	Se	8	3	0.12-0.25	0.18	0.06
	Tl	16	6	0.01-0.17	0.06	0.06
	V	8		0.5-2.9	1.2	0.8
	Zn	16		12-30	19	5
White Rock						
15 WR Fire Station	Ag	18		0.04-0.27	0.14	0.08
	As	9		0.06-0.39	0.22	0.10
	Ba	18		5-26	14	6
	Be	9		0.02-0.08	0.04	0.02
	Cd	18	1	0.01-0.19	0.09	0.05
	Co	18		0.03-0.43	0.21	0.10
	Cr	18		0.5-2.2	1.4	0.6
	Cu	18		38-82	62	13
	Ni	18		0.7-1.5	1.1	0.3
	Pb	18		1.2-5.3	2.5	1.2
	Sb	18		0.21-0.82	0.50	0.17
	Se	9	4	0.13-0.40	0.20	0.12
	Tl	18	5	0.04-0.16	0.07	0.03
	V	9		0.5-2.5	1.5	0.7
	Zn	18		10-26	18	6

4. Air Surveillance

Table 4-20. Total Suspended Particulate Matter Elemental Ratios

Element Ratio	On-Site Soil Average from 2000 ESR	Station 81 for 2001	Station 61 for 2001	Station 15 for 2001
Ag/Ba	< 0.02	0.01	0.01	0.01
As/Ba	0.02	0.01	0.02	0.02
Be/Ba	0.008	0.0025	0.004	0.003
Cd/Ba	< 0.004	0.0045	0.01	0.01
Co/Ba	0.06	0.01	0.01	0.02
Cr/Ba	0.08	0.1	0.1	0.1
Cu/Ba	0.05	2.0	2.6	4.4
Ni/Ba	0.07	0.08	0.09	0.08
Pb/Ba	0.16	0.16	0.24	0.18
Sb/Ba	< 0.002	0.03	0.04	0.04
Se/Ba	0.005	0.01	0.02	0.01
Tl/Ba	0.002	0.001	0.01	0.01
V/Ba	0.15	0.09	0.1	0.11
Zn/Ba	0.4	1.2	1.6	1.3

4. Air Surveillance

Table 4-21. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the White Rock Fire Station (ppbv)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
1,1,1-Trichloroethane	71-55-6	8	0	0.031–0.086	0.054	0.021
1,1,2,2-Tetrachloroethane	79-34-5	8	8	<0.047		
1,1-Dichloroethene	75-35-4	8	8	<0.01		
1,2,3-Trimethylbenzene	526-73-8	8	4	0.015–0.028	0.020	0.006
1,2,4-Trichlorobenzene	120-82-1	8	7	0.05	0.050	
1,2,4-Trimethylbenzene	95-63-6	8	0	0.025–0.15	0.078	0.040
1,2-Dichlorobenzene	95-50-1	8	7	0.018	0.018	
1,3,5-Trimethylbenzene	108-67-8	8	2	0.0095–0.048	0.028	0.012
1,3-Butadiene	106-99-0	8	1	0.028–0.12	0.068	0.030
1,3-Dichlorobenzene	541-73-1	8	7	0.01	0.010	
1,4-Dichlorobenzene	106-46-7	8	6	0.015–0.021	0.018	
1-Butanol	71-36-3	8	5	0.025–0.37	0.170	0.180
1-Butene/Isobutene	106-98-9	8	0	0.092–2.3	0.470	0.700
1-Heptene	592-76-7	8	0	0.028–0.41	0.110	0.130
1-Hexene	592-41-6	8	2	0.014–0.23	0.061	0.080
1-Methylcyclopentene	693-89-0	8	6	0.042–0.21	0.130	
1-Nonene	124-11-8	8	7	0.015	0.015	
1-Octene	111-66-0	8	7	0.0071	0.007	
1-Pentene	109-67-1	8	0	0.066–1.6	0.320	0.500
1-Propanol	71-23-8	8	6	0.24–0.41	0.330	
1-Undecene	821-95-4	8	4	0.011–0.15	0.065	0.060
2,2,3-Trimethylpentane	564-02-3	8	2	0.012–0.065	0.024	0.020
2,2,4-Trimethylpentane	540-84-1	8	0	0.037–0.91	0.220	0.290
2,2,5-Trimethylhexane	3522-94-9	8	4	0.014–0.028	0.019	0.007
2,2-Dimethylbutane	75-83-2	8	0	0.024–1.2	0.200	0.400
2,3,4-Trimethylpentane	565-75-3	8	1	0.076–0.21	0.120	0.040
2,3-Dimethylbutane	79-29-8	8	0	0.048–1.9	0.350	0.600
2,3-Dimethylpentane	565-59-3	8	0	0.048–0.92	0.230	0.290
2,4,4-Trimethyl-1-pentene	107-39-1	8	7	0.012	0.012	
2,4-Dimethylpentane	108-08-7	8	0	0.027–0.61	0.140	0.200
2,5-Dimethylhexane	592-13-2	8	2	0.011–0.071	0.020	0.020
2-Butanone (Methyl Ethyl Ketone)	78-93-3	8	0	0.18–1.8	0.530	0.500
2-Ethyl-1-butene	760-21-4	8	7	0.014	0.014	
2-Ethyltoluene	611-14-3	8	2	0.012–0.034	0.022	0.008
2-Methyl-1-pentene	763-29-1	8	2	0.0088–0.23	0.056	0.090
2-Methyl-2-butene	513-35-9	8	0	0.07–4.9	0.780	1.700
2-Methyl-2-pentene	625-27-4	8	0	0.011–0.34	0.066	0.100
2-Methylbutane	78-78-4	8	0	1.2–70	12.900	23.000
2-Methylheptane	592-27-8	8	0	0.023–0.13	0.054	0.040
2-Propanol	67-63-0	8	1	0.078–0.5	0.160	0.160
3-Ethyltoluene	620-14-4	8	0	0.018–0.1	0.050	0.030
3-Methyl-1-butene	563-45-1	8	1	0.035–0.91	0.170	0.330
3-Methylheptane	589-81-1	8	3	0.0093–0.086	0.034	0.030
3-Methylhexane	589-34-4	8	0	0.1–1.0	0.280	0.300
3-Methylpentane	96-14-0	8	0	0.1–3.9	0.700	1.300
4-Ethyltoluene	622-96-8	8	2	0.012–0.05	0.029	0.013
4-Methyl-1-pentene	691-37-2	8	6	0.014–0.15	0.081	
4-Methyl-2-pentanone	108-10-1	8	6	0.021–0.32	0.170	

4. Air Surveillance

Table 4-21. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the White Rock Fire Station (ppbv) (Cont.)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
Acetaldehyde	75-07-0	8	0	2.2–12.89	4.200	3.000
Acetone	67-64-1	8	0	2.6–16	5.800	4.000
Acetonitrile	75-05-8	8	6	0.11–0.13	0.120	
Acetylene	74-86-2	8	0	0.21–2.3	1.100	0.600
alpha-Pinene	80-56-8	8	1	0.02–0.082	0.050	0.030
Benzaldehyde	100-52-7	8	1	0.21–0.61	0.360	0.160
Benzene	71-43-2	8	0	0.18–3.2	0.800	1.000
beta-Pinene	127-91-3	8	7	0.0047	0.005	
Bromomethane	74-83-9	8	7	0.02	0.020	
Butane	106-97-8	8	0	1.2–104	19.000	34.000
Butyraldehyde	123-72-8	8	0	0.14–2.8	0.530	0.900
Carbon Tetrachloride	56-23-5	8	0	0.12–0.14	0.120	0.010
Chlorobenzene	108-90-7	8	8	<0.014		
Chlorodifluoromethane	75-45-6	8	0	0.18–0.37	0.240	0.070
Chloroethane	75-00-3	8	8	<0.015		
Chloroform	67-66-3	8	4	0.0055–0.011	0.008	0.003
Chloromethane	74-87-3	8	0	0.42–0.49	0.440	0.021
cis-2-Butene	590-18-1	8	0	0.036–2.9	0.470	1.000
cis-2-Hexene	7688-21-3	8	5	0.011–0.14	0.057	0.070
cis-2-Octene	7642-04-8	8	7	0.05	0.050	
cis-2-Pentene	627-20-3	8	0	0.037–1.8	0.320	0.600
cis-3-Heptene	7642-10-6	8	7	0.15	0.150	
cis-3-Hexene	7642-09-3	8	3	0.0082–0.15	0.043	0.060
cis-3-Methyl-2-pentene	922-62-3	8	5	0.0055–0.16	0.063	0.080
cis/trans-4-Methyl-2-pentene	691-38-3	8	2	0.0034–0.23	0.049	0.090
Cyclohexane	110-82-7	8	0	0.032–1.0	0.210	0.330
Cyclopentane	287-92-3	8	0	0.034–1.5	0.250	0.500
Cyclopentene	142-29-0	8	2	0.014–0.3	0.069	0.100
Dichlorofluoromethane	75-43-4	8	8	<0.014		
Ethane	74-84-0	8	0	2.6–21	7.100	6.000
Ethanol	64-17-5	8	0	3.4–11.7	7.600	2.800
Ethyl Benzene	100-41-4	8	0	0.036–0.28	0.120	0.070
Ethylene	74-85-1	8	0	0.41–2.5	1.500	0.700
Freon 11	75-69-4	8	0	0.28–0.31	0.290	0.011
Freon 113	76-13-1	8	0	0.066–0.086	0.074	0.006
Freon 114	76-14-2	8	0	0.011–0.014	0.012	0.001
Freon 12	75-71-8	8	0	0.56–0.61	0.590	0.020
Halocarbon 134A	811-97-2	8	0	0.029–0.097	0.049	0.021
Heptanal	111-71-7	8	6	0.048–0.19	0.120	
Heptane	142-82-5	8	0	0.024–0.58	0.140	0.180
Hexachlorobutadiene	87-68-3	8	7	0.022	0.022	
Hexanal	66-25-1	8	1	0.036–0.72	0.210	0.230
Hexane	110-54-3	8	0	0.098–3.8	0.700	1.200
Indan	496-11-7	8	8	<0.23		
Isobutane	75-28-5	8	0	0.45–32	5.300	11.000
Isoheptane	31394-5	8	0	0.048–1.7	0.330	0.600
Isohexane	107-83-5	8	0	0.2–6.7	1.200	2.200
Isoprene	78-79-5	8	3	0.019–0.11	0.050	0.040
Limonene	138-86-3	8	7	0.02	0.020	

Table 4-21. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the White Rock Fire Station (ppbv) (Cont.)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
Methanol	67-56-1	8	0	5.6–19	10.400	4.000
Methyl tert-Butyl Ether	1634-04-4	8	7	0.017	0.017	
Methylcyclohexane	108-87-2	8	0	0.0088–0.38	0.086	0.100
Methylcyclopentane	96-37-7	8	0	0.054–2.3	0.410	0.800
Methylene Chloride	75-09-2	8	0	0.023–0.083	0.056	0.021
n-Decane	124-18-5	8	1	0.009–0.027	0.017	0.007
n-Nonane	111-84-2	8	1	0.013–0.08	0.040	0.030
n-Octane	111-65-9	8	0	0.021–0.12	0.050	0.040
n-Propylbenzene	103-65-1	8	4	0.018–0.038	0.025	0.009
n-Undecane	1120-21-4	8	1	0.0056–0.027	0.017	0.009
Naphthalene	91-20-3	8	8	<0.08		
Neopentane	463-82-1	8	1	0.014–0.48	0.092	0.170
o-Xylene	95-47-6	8	0	0.052–0.34	0.150	0.090
p-Xylene/m-Xylene	106-42-3	8	0	0.1–0.943	0.370	0.260
Pentane	109-66-0	8	0	0.52–23	4.000	8.000
Propane	74-98-6	8	0	1–14.9	4.200	5.000
Propylene	115-07-1	8	0	0.094–0.98	0.390	0.270
Styrene	100-42-5	8	4	0.015–0.02	0.018	0.002
Tetrachloroethene	127-18-4	8	8	<0.04		
Toluene	108-88-3	8	0	0.3–3.4	1.100	1.000
trans-2-Butene	624-64-6	8	0	0.045–2.9	0.480	1.000
trans-2-Heptene	14686-1	8	7	0.035	0.035	
trans-2-Hexene	4050-45-7	8	1	0.014–0.28	0.065	0.100
trans-2-Pentene	646-04-8	8	0	0.095–3.6	0.620	1.200
trans-3-Heptene	14686-1	8	7	0.091	0.091	
Trichloroethene	79-01-6	8	8	<0.04		
Vinyl Acetate	108-05-4	8	7	0.54	0.540	

4. Air Surveillance

Table 4-22. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Los Alamos Hospital (ppbv)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
1,1,1-Trichloroethane	71-55-6	7	0	0.032–0.039	0.035	0.002
1,1,2,2-Tetrachloroethane	79-34-5	7	6	0.013	0.013	
1,1-Dichloroethene	75-35-4	7	6	0.018	0.018	
1,2,3-Trimethylbenzene	526-73-8	7	5	0.015–0.029	0.022	
1,2,4-Trichlorobenzene	120-82-1	7	6	0.034	0.034	
1,2,4-Trimethylbenzene	95-63-6	7	0	0.032–0.14	0.068	0.040
1,2-Dichlorobenzene	95-50-1	7	6	0.021	0.021	
1,3,5-Trimethylbenzene	108-67-8	7	3	0.016–0.046	0.026	0.014
1,3-Butadiene	106-99-0	7	1	0.016–0.096	0.060	0.030
1,3-Dichlorobenzene	541-73-1	7	6	0.019	0.019	
1,4-Dichlorobenzene	106-46-7	7	6	0.03	0.030	
1-Butanol	71-36-3	7	5	0.22–0.59	0.460	
1-Butene/Isobutene	106-98-9	7	0	0.082–0.8	0.311	0.300
1-Heptene	592-76-7	7	5	0.037–0.038	0.038	
1-Hexene	592-41-6	7	5	0.04–0.04	0.040	
1-Methylcyclopentene	693-89-0	7	7	<0.015		
1-Nonene	124-11-8	7	6	0.022	0.022	
1-Octene	111-66-0	7	6	0.02	0.020	
1-Pentene	109-67-1	7	1	0.028–0.11	0.052	0.040
1-Propanol	71-23-8	7	5	0.7–1.1	0.900	
1-Undecene	821-95-4	7	6	0.028	0.028	
2,2,3-Trimethylpentane	564-02-3	7	3	0.0086–0.04	0.020	0.014
2,2,4-Trimethylpentane	540-84-1	7	0	0.023–0.84	0.210	0.300
2,2,5-Trimethylhexane	3522-94-9	7	5	0.0098–0.025	0.017	
2,2-Dimethylbutane	75-83-2	7	1	0.011–0.1	0.034	0.030
2,3,4-Trimethylpentane	565-75-3	7	1	0.076–0.15	0.100	0.030
2,3-Dimethylbutane	79-29-8	7	0	0.014–0.081	0.040	0.020
2,3-Dimethylpentane	565-59-3	7	0	0.023–0.13	0.068	0.040
2,4,4-Trimethyl-1-pentene	107-39-1	7	4	0.0083–0.013	0.011	0.002
2,4-Dimethylpentane	108-08-7	7	0	0.015–0.12	0.043	0.040
2,5-Dimethylhexane	592-13-2	7	3	0.012–0.042	0.023	0.014
2-Butanone (Methyl Ethyl Ketone)	78-93-3	7	0	0.13–2.7	0.900	1.100
2-Ethyl-1-butene	760-21-4	7	6	0.024	0.024	
2-Ethyltoluene	611-14-3	7	3	0.012–0.032	0.023	0.008
2-Methyl-1-pentene	763-29-1	7	5	0.0095–0.032	0.020	
2-Methyl-2-butene	513-35-9	7	2	0.011–0.13	0.047	0.050
2-Methyl-2-pentene	625-27-4	7	4	0.0088–0.031	0.018	0.012
2-Methylbutane	78-78-4	7	0	0.54–2.6	1.200	0.700
2-Methylheptane	592-27-8	7	2	0.017–0.43	0.140	0.170
2-Propanol	67-63-0	7	0	0.053–0.91	0.320	0.300
3-Ethyltoluene	620-14-4	7	0	0.019–0.092	0.050	0.030
3-Methyl-1-butene	563-45-1	7	6	0.019	0.019	
3-Methylheptane	589-81-1	7	4	0.0091–0.024	0.018	0.008
3-Methylhexane	589-34-4	7	1	0.054–0.16	0.100	0.040
3-Methylpentane	96-14-0	7	0	0.036–0.18	0.090	0.050
4-Ethyltoluene	622-96-8	7	3	0.019–0.041	0.030	0.009
4-Methyl-1-pentene	691-37-2	7	6	0.039	0.039	
4-Methyl-2-pentanone	108-10-1	7	5	0.32–0.59	0.450	

Table 4-22. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Los Alamos Hospital (ppbv) (Cont.)

Compound Name	Chemical Abstract Service	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
	Compound Number					
Acetaldehyde	75-07-0	7	0	2.6–22	8.600	8.000
Acetone	67-64-1	7	0	2.3–27	9.800	1
Acetonitrile	75-05-8	7	2	0.085–0.24	0.150	0.060
Acetylene	74-86-2	7	0	0.91–2.5	1.600	0.600
alpha-Pinene	80-56-8	7	1	0.015–0.08	0.050	0.020
Benzaldehyde	100-52-7	7	0	0.035–0.44	0.220	0.140
Benzene	71-43-2	7	0	0.18–0.62	0.370	0.180
beta-Pinene	127-91-3	7	6	0.0091	0.009	
Bromomethane	74-83-9	7	6	0.033	0.033	
Butane	106-97-8	7	0	0.55–2.3	1.100	0.700
Butyraldehyde	123-72-8	7	0	0.092–4.2	1.000	1.600
Carbon Tetrachloride	56-23-5	7	0	0.11–0.13	0.120	0.010
Chlorobenzene	108-90-7	7	2	0.0069–0.018	0.011	0.004
Chlorodifluoromethane	75-45-6	7	0	0.18–0.22	0.200	0.015
Chloroethane	75-00-3	7	4	0.038–0.072	0.058	0.018
Chloroform	67-66-3	7	2	0.0049–0.01	0.008	0.002
Chloromethane	74-87-3	7	0	0.42–0.5	0.460	0.020
cis-2-Butene	590-18-1	7	3	0.023–0.065	0.040	0.018
cis-2-Hexene	7688-21-3	7	7	<0.01		
cis-2-Octene	7642-04-8	7	6	0.056	0.056	
cis-2-Pentene	627-20-3	7	5	0.02–0.036	0.028	
cis-3-Heptene	7642-10-6	7	7	<0.08		
cis-3-Hexene	7642-09-3	7	7	<0.02		
cis-3-Methyl-2-pentene	922-62-3	7	7	<0.01		
cis/trans-4-Methyl-2-pentene	691-38-3	7	5	0.0033–0.0095	0.006	
Cyclohexane	110-82-7	7	1	0.018–0.1	0.053	0.030
Cyclopentane	287-92-3	7	3	0.016–0.045	0.031	0.012
Cyclopentene	142-29-0	7	7	<0.03		
Dichlorofluoromethane	75-43-4	7	7	<0.015		
Ethane	74-84-0	7	0	3.4–17	6.400	5.000
Ethanol	64-17-5	7	0	8.4–19	14.000	4.000
Ethyl Benzene	100-41-4	7	0	0.031–0.16	0.088	0.050
Ethylene	74-85-1	7	0	0.91–2.8	1.900	0.800
Freon 11	75-69-4	7	0	0.28–0.33	0.320	0.020
Freon 113	76-13-1	7	0	0.063–0.11	0.074	0.015
Freon 114	76-14-2	7	0	0.0091–0.016	0.011	0.002
Freon 12	75-71-8	7	0	0.56–0.62	0.580	0.020
Halocarbon 134A	811-97-2	7	0	0.032–0.16	0.068	0.040
Heptanal	111-71-7	7	5	0.12–1.2	0.660	
Heptane	142-82-5	7	1	0.025–0.11	0.057	0.040
Hexachlorobutadiene	87-68-3	7	6	0.024	0.024	
Hexanal	66-25-1	7	1	0.059–2.9	0.650	1.100
Hexane	110-54-3	7	0	0.044–0.22	0.120	0.060
Indan	496-11-7	7	6	0.012	0.012	
Isobutane	75-28-5	7	0	0.19–0.77	0.320	0.210
Isoheptane	31394-5	7	1	0.027–1.0	0.220	0.390
Isohexane	107-83-5	7	0	0.1–0.43	0.220	0.120
Isoprene	78-79-5	7	3	0.018–0.073	0.040	0.020
Limonene	138-86-3	7	6	0.029	0.029	

4. Air Surveillance

Table 4-22. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Los Alamos Hospital (ppbv) (Cont.)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
Methanol	67-56-1	7	0	4.5–14.3	9.000	3.000
Methyl tert-Butyl Ether	1634-04-4	7	6	0.0086	0.009	
Methylcyclohexane	108-87-2	7	2	0.012–0.096	0.052	0.030
Methylcyclopentane	96-37-7	7	0	0.019–0.13	0.063	0.040
Methylene Chloride	75-09-2	7	0	0.037–0.44	0.120	0.150
n-Decane	124-18-5	7	1	0.003–0.024	0.010	0.010
n-Nonane	111-84-2	7	0	0.012–0.46	0.082	0.160
n-Octane	111-65-9	7	0	0.02–0.064	0.034	0.016
n-Propylbenzene	103-65-1	7	6	0.03	0.030	
n-Undecane	1120-21-4	7	4	0.0052–0.0085	0.007	0.002
Naphthalene	91-20-3	7	6	0.032	0.032	
Neopentane	463-82-1	7	6	0.0056	0.006	
o-Xylene	95-47-6	7	0	0.044–0.21	0.120	0.070
p-Xylene/m-Xylene	106-42-3	7	0	0.093–0.5	0.270	0.170
Pentane	109-66-0	7	0	0.14–0.57	0.330	0.160
Propane	74-98-6	7	0	0.99–4.6	1.800	1.200
Propylene	115-07-1	7	0	0.12–0.69	0.360	0.220
Styrene	100-42-5	7	3	0.012–0.038	0.024	0.012
Tetrachloroethene	127-18-4	7	7	<0.04		
Toluene	108-88-3	7	0	0.26–1.2	0.620	0.350
trans-2-Butene	624-64-6	7	2	0.019–0.068	0.040	0.018
trans-2-Heptene	14686-1	7	7	<0.02		
trans-2-Hexene	4050-45-7	7	5	0.0067–0.018	0.012	
trans-2-Pentene	646-04-8	7	0	0.012–0.074	0.031	0.021
trans-3-Heptene	14686-1	7	6	0.045	0.045	
Trichloroethene	79-01-6	7	7	<0.045		
Vinyl Acetate	108-05-4	7	2	0.3–1.2	0.700	0.400

4. Air Surveillance

Table 4-23. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Intersection of Diamond Drive & East Jemez Roads in Los Alamos (ppbv)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Range	Mean	Standard Deviation
1,1,1-Trichloroethane	71-55-6	8	1	0.032–0.042	0.036	0.003
1,1,2,2-Tetrachloroethane	79-34-5	8	7	0.023	0.023	
1,1-Dichloroethene	75-35-4	8	8	<0.01		
1,2,3-Trimethylbenzene	526-73-8	8	7	0.027	0.027	
1,2,4-Trichlorobenzene	120-82-1	8	6	0.006–0.0089	0.007	
1,2,4-Trimethylbenzene	95-63-6	8	1	0.015–0.11	0.070	0.040
1,2-Dichlorobenzene	95-50-1	8	7	0.056	0.056	
1,3,5-Trimethylbenzene	108-67-8	8	3	0.015–0.051	0.029	0.014
1,3-Butadiene	106-99-0	8	2	0.022–0.091	0.060	0.030
1,3-Dichlorobenzene	541-73-1	8	7	0.044	0.044	
1,4-Dichlorobenzene	106-46-7	8	7	0.044	0.044	
1-Butanol	71-36-3	8	5	0.071–0.25	0.160	0.090
1-Butene/Isobutene	106-98-9	8	1	0.056–0.31	0.170	0.080
1-Heptene	592-76-7	8	3	0.024–0.089	0.050	0.020
1-Hexene	592-41-6	8	4	0.02–0.034	0.026	0.006
1-Methylcyclopentene	693-89-0	8	8	<0.014		
1-Nonene	124-11-8	8	7	0.019	0.019	
1-Octene	111-66-0	8	7	0.0072	0.007	
1-Pentene	109-67-1	8	2	0.034–0.079	0.054	0.017
1-Propanol	71-23-8	8	7	0.92	0.920	
1-Undecene	821-95-4	8	7	0.0094	0.009	
2,2,3-Trimethylpentane	564-02-3	8	4	0.0061–0.02	0.012	0.006
2,2,4-Trimethylpentane	540-84-1	8	1	0.0097–0.17	0.070	0.050
2,2,5-Trimethylhexane	3522-94-9	8	5	0.0052–0.022	0.014	0.008
2,2-Dimethylbutane	75-83-2	8	3	0.016–0.03	0.022	0.006
2,3,4-Trimethylpentane	565-75-3	8	3	0.084–0.14	0.100	
2,3-Dimethylbutane	79-29-8	8	2	0.024–0.083	0.046	0.021
2,3-Dimethylpentane	565-59-3	8	2	0.038–0.16	0.082	0.040
2,4,4-Trimethyl-1-pentene	107-39-1	8	5	0.0078–0.014	0.012	0.003
2,4-Dimethylpentane	108-08-7	8	2	0.022–0.076	0.042	0.020
2,5-Dimethylhexane	592-13-2	8	5	0.0092–0.025	0.016	0.008
2-Butanone (Methyl Ethyl Ketone)	78-93-3	8	0	0.083–0.4	0.230	0.100
2-Ethyl-1-butene	760-21-4	8	8	<0.019		
2-Ethyltoluene	611-14-3	8	5	0.018–0.031	0.023	0.007
2-Methyl-1-pentene	763-29-1	8	8	<0.015		
2-Methyl-2-butene	513-35-9	8	2	0.012–0.068	0.040	0.020
2-Methyl-2-pentene	625-27-4	8	6	0.015–0.018	0.017	
2-Methylbutane	78-78-4	8	0	0.074–2.1	0.890	0.600
2-Methylheptane	592-27-8	8	3	0.03–0.069	0.047	0.015
2-Propanol	67-63-0	8	3	0.085–0.19	0.120	0.040
3-Ethyltoluene	620-14-4	8	2	0.021–0.076	0.048	0.020
3-Methyl-1-butene	563-45-1	8	8	<0.01		
3-Methylheptane	589-81-1	8	5	0.015–0.021	0.018	0.003
3-Methylhexane	589-34-4	8	3	0.089–0.16	0.110	0.030
3-Methylpentane	96-14-0	8	1	0.015–0.2	0.100	0.070
4-Ethyltoluene	622-96-8	8	4	0.023–0.051	0.035	0.013
4-Methyl-1-pentene	691-37-2	8	7	0.0089	0.009	
4-Methyl-2-pentanone	108-10-1	8	4	0.05–0.086	0.064	0.016

4. Air Surveillance

Table 4-23. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Intersection of Diamond Drive & East Jemez Roads in Los Alamos (ppbv) (Cont.)

Compound Name	Chemical Abstract Service	Number of Measurements	Number of Measurements		Mean	Standard Deviation
	Compound Number		<Detection Limit	Range		
Acetaldehyde	75-07-0	8	0	1.1–8.7	4.000	2.800
Acetone	67-64-1	8	0	1.2–5.4	3.600	1.500
Acetonitrile	75-05-8	8	5	0.1–0.16	0.130	0.030
Acetylene	74-86-2	8	0	0.19–1.8	0.980	0.600
alpha-Pinene	80-56-8	8	4	0.019–0.087	0.042	0.030
Benzaldehyde	100-52-7	8	3	0.1–1.0	0.460	0.350
Benzene	71-43-2	8	0	0.04–0.53	0.311	0.180
beta-Pinene	127-91-3	8	7	0.0072	0.007	
Bromomethane	74-83-9	8	8	<0.03		
Butane	106-97-8	8	0	0.15–2	0.960	0.700
Butyraldehyde	123-72-8	8	1	0.053–0.35	0.190	0.100
Carbon Tetrachloride	56-23-5	8	0	0.027–0.14	0.120	0.040
Chlorobenzene	108-90-7	8	8	<0.014		
Chlorodifluoromethane	75-45-6	8	0	0.11–0.82	0.290	0.220
Chloroethane	75-00-3	8	8	<0.015		
Chloroform	67-66-3	8	4	0.0055–0.018	0.010	0.005
Chloromethane	74-87-3	8	0	0.15–0.49	0.460	0.100
cis-2-Butene	590-18-1	8	5	0.038–0.05	0.042	0.006
cis-2-Hexene	7688-21-3	8	8	<0.01		
cis-2-Octene	7642-04-8	8	8	<0.03		
cis-2-Pentene	627-20-3	8	5	0.024–0.037	0.028	0.007
cis-3-Heptene	7642-10-6	8	8	<0.08		
cis-3-Hexene	7642-09-3	8	8	<0.02		
cis-3-Methyl-2-pentene	922-62-3	8	8	<0.01		
cis/trans-4-Methyl-2-pentene	691-38-3	8	8	<0.009		
Cyclohexane	110-82-7	8	2	0.03–0.12	0.070	0.040
Cyclopentane	287-92-3	8	3	0.018–0.045	0.033	0.011
Cyclopentene	142-29-0	8	6	0.011–0.025	0.018	
Dichlorofluoromethane	75-43-4	8	7	0.0096	0.010	
Ethane	74-84-0	8	0	1.1–14.3	5.600	4.000
Ethanol	64-17-5	8	0	5–19	10.900	5.000
Ethyl Benzene	100-41-4	8	1	0.024–0.15	0.088	0.040
Ethylene	74-85-1	8	0	0.31–2.5	1.480	0.800
Freon 11	75-69-4	8	0	0.078–0.31	0.270	0.080
Freon 113	76-13-1	8	0	0.015–0.081	0.065	0.021
Freon 114	76-14-2	8	1	0.009–0.016	0.011	0.002
Freon 12	75-71-8	8	0	0.16–0.59	0.530	0.150
Halocarbon 134A	811-97-2	8	1	0.023–0.16	0.056	0.050
Heptanal	111-71-7	8	7	0.04	0.040	
Heptane	142-82-5	8	2	0.021–0.093	0.060	0.020
Hexachlorobutadiene	87-68-3	8	7	0.14	0.140	
Hexanal	66-25-1	8	4	0.059–0.25	0.120	0.090
Hexane	110-54-3	8	1	0.022–0.73	0.210	0.240
Indan	496-11-7	8	8	<0.23		
Isobutane	75-28-5	8	0	0.044–0.77	0.320	0.280
Isoheptane	31394-5	8	2	0.04–0.12	0.090	0.030
Isohexane	107-83-5	8	1	0.035–0.33	0.180	0.100
Isoprene	78-79-5	8	3	0.012–0.054	0.034	0.016
Limonene	138-86-3	8	8	<0.029		

Table 4-23. Air Concentration Summary of Volatile Organic Compounds Measured in 2001 at the Intersection of Diamond Drive & East Jemez Roads in Los Alamos (ppbv) (Cont.)

Compound Name	Chemical Abstract Service	Number of Measurements	Number of Measurements		Mean	Standard Deviation
	Compound Number		<Detection Limit	Range		
Methanol	67-56-1	8	0	1.2–7.4	4.600	2.000
Methyl tert-Butyl Ether	1634-04-4	8	8	<0.013		
Methylcyclohexane	108-87-2	8	2	0.008–0.12	0.047	0.040
Methylcyclopentane	96-37-7	8	1	0.0063–0.22	0.083	0.070
Methylene Chloride	75-09-2	8	1	0.026–0.26	0.077	0.080
n-Decane	124-18-5	8	2	0.0061–0.024	0.015	0.006
n-Nonane	111-84-2	8	1	0.011–0.044	0.026	0.011
n-Octane	111-65-9	8	3	0.033–0.055	0.043	0.008
n-Propylbenzene	103-65-1	8	6	0.023–0.027	0.025	
n-Undecane	1120-21-4	8	5	0.0094–0.02	0.016	0.006
Naphthalene	91-20-3	8	8	<0.08		
Neopentane	463-82-1	8	6	0.0082–0.009	0.009	
o-Xylene	95-47-6	8	1	0.03–0.22	0.120	0.060
p-Xylene/m-Xylene	106-42-3	8	0	0.019–0.51	0.250	0.170
Pentane	109-66-0	8	0	0.046–0.62	0.330	0.220
Propane	74-98-6	8	0	0.35–5	1.800	1.700
Propylene	115-07-1	8	0	0.028–0.96	0.340	0.310
Styrene	100-42-5	8	5	0.017–0.032	0.022	0.008
Tetrachloroethene	127-18-4	8	6	0.011–0.013	0.012	
Toluene	108-88-3	8	0	0.052–0.98	0.540	0.360
trans-2-Butene	624-64-6	8	4	0.034–0.057	0.043	0.011
trans-2-Heptene	14686-1	8	8	<0.017		
trans-2-Hexene	4050-45-7	8	7	0.016	0.016	
trans-2-Pentene	646-04-8	8	2	0.016–0.075	0.040	0.020
trans-3-Heptene	14686-1	8	7	0.1	0.100	
Trichloroethene	79-01-6	8	5	0.016–0.042	0.031	0.013
Vinyl Acetate	108-05-4	8	7	0.45	0.450	

4. Air Surveillance

Table 4-24. Air Concentrations of Volatile Organic Compounds Not Detected at any Site in 2001 (ppbv)

Compound Name	Chemical Abstract Service Compound Number	Number of Measurements	Number of Measurements <Detection Limit	Maximum Air Concentration
1,1,2-Trichloroethane	79-00-5	23	23	<0.022
1,1-Dichloroethane	75-34-3	23	23	<0.016
1,2-Dichloroethane	107-06-2	23	23	<0.02
1,2-Dichloropropane	78-87-5	23	23	<0.02
1,3-Diethylbenzene	141-93-5	23	23	<0.02
1,4-Diethylbenzene	105-05-5	23	23	<0.02
1,4-Dioxane	123-91-1	23	23	<0.09
1-Decene	872-05-9	23	23	<0.33
1-Methylcyclohexene	591-49-1	23	23	<0.03
2,4,4-Trimethyl-2-pentene	107-40-4	23	23	<0.02
2-Chloro-1,3-butadiene	126-99-8	23	23	<0.02
2/3-Chlorotoluene	2/3-CT	23	23	<0.6
4-Chlorotoluene	106-43-4	23	23	<0.33
4-Isopropyltoluene	99-87-6	23	23	<0.27
4-Nonene	2198-23-4	23	23	<0.04
Acrylonitrile	107-13-1	23	23	<0.04
Bromochloromethane	74-97-5	23	23	<0.007
Bromodichloromethane	75-27-4	23	23	<0.02
Bromoform	75-25-2	23	23	<0.01
Butyl acrylate	141-32-2	23	23	<0.2
Chlorotoluene	100-44-7	23	23	<0.06
cis-1,2 Dichloroethene	156-59-2	23	23	<0.04
cis-1,3-Dichloropropene	10061-01-5	23	23	<0.02
Cyclohexene	110-83-8	23	23	<0.03
Dibromochloromethane	124-48-1	23	23	<0.02
Diethyl ether	60-29-7	23	23	<0.03
Ethylene Dibromide	106-93-4	23	23	<0.008
Indene	95-13-6	23	23	<0.01
Isobutylbenzene	538-93-2	23	23	<0.35
Isopropylbenzene	98-82-8	23	23	<0.01
n-Butylbenzene	104-51-8	23	23	<0.24
tert-Butylbenzene	98-06-6	23	23	<0.4
trans-1,2-Dichloroethene	156-60-5	23	23	<0.02
trans-1,3-Dichloropropene	10061-02-6	23	23	<0.03
Vinyl bromide	593-60-2	23	23	<0.016
Vinyl Chloride	75-01-4	23	23	<0.016

Table 4-25. DX Division Firing Sites Expenditures for Calendar Year 2000–2001

(All units are in kilograms unless otherwise noted.)

Materials Expended	Material Totals	Material Totals
	2000	2001
HE	2,403	2,558
Aluminum	394	78
Beryllium	2.0	52
Beryllium Oxide	NR	54
Boron	NR	0.13
Brass	148	0
Carbon Phenolic	NR	1.4
Copper	88	24
Depleted Uranium	419	536
DPB plus Teflon	NR	0.011
Foam	5.0	8.6
Lead	5.0	0
Lexan	1.0	0
Lithium	NR	21.6
Molybdenum	3.0	0
Plastic	2.0	7.1
RHA Steel	NR	55
Rubber	NR	20.4
Silver	0.8	0
Stainless Steel	677	270
Tin	0.27	1.0
Tantalum	1.2	12
TMBA	NR	1.1
Tungsten	18.6	0
Teflon	NR	0
Uranium Niobium	NR	232
Uranium	NR	14
Wood	NR	10

Notes: NR = not reported

4. Air Surveillance

Table 4-26. Airborne Beryllium Concentrations

Station Location	Number of Measurements	Maximum (ng/m ³)	Minimum (ng/m ³)	Mean (ng/m ³)	Sample Standard Deviation
Regional/Pueblo Stations					
01 Española	4	0.034	0.019	0.025	0.007
03 Santa Fe	4	0.077	0.018	0.039	0.027
41 San Ildefonso Pueblo	4	0.047	0.015	0.028	0.014
55 Santa Fe West (Buckman Booster #4)	4	0.017	0.007	0.012	0.004
56 El Rancho	4	0.023	0.007	0.016	0.008
59 Jemez Pueblo-Visitor's Center	4	0.077	0.038	0.061	0.017
Perimeter Stations					
04 Barranca School	4	0.030	0.011	0.020	0.010
09 Los Alamos Airport	4	0.011	0.005	0.008	0.003
10 East Gate	4	0.019	0.009	0.012	0.005
12 Royal Crest Trailer Court	4	0.024	0.006	0.014	0.007
16 White Rock Nazarene Church	4	0.011	0.006	0.008	0.002
26 TA-49	4	0.016	0.005	0.009	0.005
32 County Landfill	4	0.104	0.063	0.087	0.018
39 TA-49-QA (next to #26)	4	0.022	0.006	0.011	0.007
61 LA Hospital	4	0.017	0.014	0.015	0.002
68 Airport Road	1	0.011	0.011	0.011	
80 Western Arizona Street	2	0.024	0.013	0.019	0.008
90 East Gate-Backup	2	0.012	0.011	0.012	0.001
On-Site Stations					
20 TA-21 Area B	4	0.016	0.007	0.010	0.004
23 TA-5	4	0.022	0.009	0.015	0.007
31 TA-3	4	0.028	0.011	0.017	0.007
71 TA-21.01 (NW Bldg 344)	4	0.018	0.006	0.010	0.005
76 TA-15-41	4	0.020	0.003	0.010	0.007
77 TA-36 IJ Site	4	0.014	0.004	0.008	0.004
78 TA-15-N	4	0.011	0.003	0.006	0.003
TA-54 Area G Stations					
27 Area G (by QA)	4	0.093	0.018	0.038	0.037
35 Area G-2 (back fence)	4	0.039	0.013	0.023	0.011
36 Area G-3 (by office)	4	0.036	0.010	0.017	0.012
38 Area G-QA (next to #27)	4	0.088	0.026	0.042	0.030

Group Summaries

Station Location	Number of Measurements	Maximum (ng/m ³)	Minimum (ng/m ³)	Mean (ng/m ³)	95% Confidence Interval ^a	Sample Standard Deviation
Regional/Pueblo Stations	24	0.077	0.007	0.030	±0.009	0.021
Perimeter Stations	41	0.104	0.005	0.020	±0.007	0.024
On-Site Stations	28	0.028	0.003	0.011	±0.002	0.006
TA-54 Area G Stations	16	0.093	0.010	0.030	±0.013	0.025

^a95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-27. AIRNET QC Sample Types

Analyte	Number of Samples	Number of Lab Control Standards	Number of Matrix Spikes	Number of Matrix Blanks	Number of Matrix Replicates	Number of Process Blanks	Number of Trip Blanks
Alpha/Beta	1,371	87		186	83		127
Americium-241	226	15	15	33		15	20
Beryllium	288	25	25	70		24	20
Gamma Nuclides	344	39		44	37	39	46
Lead-210	736	55	55	139		55	89
Plutonium Isotopes	226	15	15	33		15	20
Polonium-210	736	54	54	138		54	89
Stable Elements (except Beryllium)	288	25	25	70		24	20
Tritium	1,316	168	123	78	45	168	127
Uranium Isotopes	381	26	27	78		27	20

Table 4-28. Stack QC Sample Types

Analyte	Number of Samples	Number of Lab Control Standards	Number of Matrix Spikes	Number of Matrix Blanks	Number of Matrix Replicates	Number of Process Blanks	Number of Trip Blanks
Alpha/Beta	1,866	5	107	111	104	5	106
Americium-241	79	5	5	9	2	5	4
Beryllium	56	102	51	51	1	51	51
Gamma Nuclides	2,223	5		416	261	211	108
Lead-210	79	5	5	9	2	5	4
Plutonium Isotopes	79	5	5	9	2	5	4
Polonium-210	79	5	5	9	2	5	4
Strontium-90	79	5	5	9	2	5	4
Thorium Isotopes	79	5	5	9	2	5	4
Tritium	1,902	317	104	634	317	634	
Uranium Isotopes	79	5	5	9	2	5	4

Table 4-29. NonRadNet QC Sample Types

Analyte	Number of Samples	Number of Lab Control Standards	Number of Lab Control Replicates	Number of Matrix Spikes	Number of Matrix Blanks	Number of Process Blanks	Number of Surrogate Compound Measurements
Stable Elements	26	9		9	17	9	NA ^a
Total Suspended Particulates	27						NA
Volatile Organic Compounds	24	10	10		10		305

^aNA = not applicable.

Table 4-30. QC Performance Evaluation for AIRNET for CY 2001

Evaluation Performed	AIRNET Acceptance Criteria	Gross Alpha/Beta	Tritium	Gamma	Beryllium
Laboratory Control Standard (LCS)	100 ± 10% UC	94% UC	91.7% UC	64% UC	60% UC
Recovery Check	80 – 90 or 110 – 120% W	6% W	7.7% W	27% W	28% W
	< 80 or >120% OC		0.6% OC	9% OC	12% OC
Process Blank (PB)	See control criteria below.	NA ^a	94.6% UC 4.8% W 0.6% OC	100% UC	100% UC
Matrix Blank (MB)	See control criteria below.	95.2% UC 4.6% W 0.3% OC	95% UC 5% W	100% UC	100% UC
Trip Blank (TB)	See control criteria below.	94% UC 6% W	99.2% UC 0.8% W	100% UC	100% UC
Matrix Replicate Evaluation	For analytically significant, positive results, similar to control criteria below.	96.4% UC 3.6% W	100% UC	70% UC 29% W 1% OC	NA
Matrix Replicate Evaluation	Qualitative agreement (within a factor of 3) for analytically insignificant results (i.e. “less-than” values).	NA	NA	99.9% UC 0.1% OC	NA
Matrix Spike	100 ± 10% of added spike.	NA	1% UC 7% W 92% UC	NA	64% UC 32% W 4% OC
MDA ^b Target Achieved	All samples below SOW ^c specification.	99.7%	96.7%	75%	95%
Collection Efficiency	Between 70 and 130% of theoretical.	NA	90% UC 9% low 1% high	NA	NA
Distillation Efficiency	Between 70 and 130% of water collected.	NA	96% UC 4% high	NA	NA
Naturally Occurring Radionuclides	All should have positive results.	NA	NA	99% Yes 1% No	NA
Analytical Completeness	80% successful analysis of valid samples.	100%	99.8%	100%	100%

General Control Criteria

Under Control (UC) is ≤2s of annual mean for that QC type.

Warning (W) is between 2s and 3s of annual mean for that QC type.

Out of Control (OC) is ≥3s of annual mean for that QC type.

^aNA = not applicable.^bMinimum detectable activity.^cStatement of work.

Table 4-31. QC Performance Evaluation for AIRNET for CY 2001

Evaluation Performed	AIRNET Evaluation Criteria	²⁴¹ Am	²¹⁰ Pb	²¹⁰ Po	Plutonium Isotopes	Uranium Isotopes
Laboratory Control Standard (LCS) Recovery Check	100 ± 10% UC 80 – 90 or 110 – 120% W < 80 or >120% OC	80% UC 20% W	70% UC 30% W	18% UC 67% W 15% OC	93% UC 7% W	100% UC
Process Blank (PB)	See control criteria below.	100% UC	98% UC 2% W	96% UC 2% W 2% OC	96 % UC 4% W	95% UC 5% W
Matrix Blank (MB)	See control criteria below.	100% UC	96% UC 4% OC	96% UC 1% W 3% OC	96% UC 4% W	96% UC 4% W
Trip Blank (TB)	See control criteria below.	95% UC 5% W	93% UC 7% W	94% UC 6% OC	95% UC 3% W 2% OC	93% UC 5% W 2% OC
Matrix Spike	100 ± 10% UC 80 – 90 or 110 – 120% W < 80 or >120% OC	73% UC 27% W	67% UC 29% W 4% OC	22% UC 61% W 17% OC	87% UC 13% W	48% UC 33% W 19% OC
MDA ^a Target Achieved	All samples below SOW ^b specification.	100%	99.8%	91%	100%	98%
Analytical Completeness	80% successful analysis of valid samples.	100%	90%	90%	100%	100%
Tracer Recovery	Mean ± Standard Dev. % Recovery	74 ± 11%	89 ± 4%	60 ± 14%	74 ± 10%	67 ± 8%
Tracer Recovery Control	50 – 105% is UC	98.5%	99.9%	80.3%	99.4%	98.8%
General Control Criteria Under Control (UC) is ≤2s of annual mean for that QC type. Warning (W) is between 2s and 3s of annual mean for that QC type. Out of Control (OC) is ≥3s of annual mean for that QC type.						
^a Minimum detectable activity.						
^b Statement of work.						

Table 4-32. QC Performance Evaluation for Stack Sampling for CY 2001

Evaluation Performed	Stacks Acceptance Criteria	Alpha/Beta	Gamma	Tritium	Beryllium
Laboratory Control Standard (LCS)	100 ± 10% UC 80–90 or 110–120% W <80 or >120% OC	60% UC 40% W	90% UC 7% W 3% OC	100% UC	87% UC 13% W
Matrix Blank (MB)	See control criteria below.	97% UC 3% OC	100% UC	98.4% UC 1.4% W 0.2% OC	100% UC
Process Blank (PB)	See control criteria below.	98% UC 2% OC	99.8% UC 0.1% W	98.5% UC 1.0% W 0.5% OC	100% UC
Trip Blank (TB)	See control criteria below.	97% UC 3% OC	100% UC	NA ^a	100% UC
Matrix Duplicate Evaluation	1–10 uCi/L under control at RPD <10%.	NA	NA	100% UC	100% UC
Matrix Replicate Evaluation	For analytically significant, positive results, similar to control criteria below.	83% UC 16% W 1% OC	NA	NA	NA
Matrix Replicate Evaluation	Qualitative Agreement (within a factor of 5) for analytically insignificant results (i.e. “less-than” values).	NA	99.97%	NA	NA
Matrix Spike	Recovery of added spike: 100± 10% UC 80–90 or 110–120% W <80 or >120% OC	Alpha: 35% UC 42% W 23% OC Beta: 84% UC 15% W 1% OC	93% UC 6% W 1% OC	100% UC	NA
MDA ^b Achieved	All samples below SOW ^c specification.	98%	99.8%	100%	100%
Analytical Completeness	80% successful analysis of valid samples.	100%	100%	100%	100%

General Control Criteria

Under Control (UC) is ≤2s of annual mean for that QC type.

Warning (W) is between 2s and 3s of annual mean for that QC type.

Out of Control (OC) is ≥3s of annual mean for that QC type.

^aNA = not applicable.^bMinimum detectable activity.^cStatement of work.

4. Air Surveillance

Table 4-33. QC Performance Evaluation for Stack Sampling for CY 2001

Evaluation Performed	Stacks Acceptance Criteria	²⁴¹ Am	Thorium Isotopes	Plutonium Isotopes	Uranium Isotopes
Laboratory Control Standard (LCS) Recovery Check	100 ± 10% UC 80–90 or 110–120% W <80 or >120% OC	100% UC	80% UC 20% W	100% UC	93% UC 7% W
Matrix Blank (MB)	See control criteria below.	100% UC	100% UC	100% UC	100% UC
Process Blank (PB)	See control criteria below.	100% UC	100% UC	100% UC	100% UC
Trip Blank (TB)	See control criteria below.	100% UC	100% UC	100% UC	100% UC
Matrix Spike	Recovery of added spike: 100 ± 10% UC 80–90 or 110–120% W <80 or >120% OC	80% UC 20% W	40% UC 40% W 20% OC	90% UC 10% W	80% UC 20% W
MDA ^a Achieved	All samples below SOW ^b specification.	100% UC	100% UC	100% UC	100% UC
Analytical Completeness	80% successful analysis of valid samples.	100%	100%	100%	100%
Tracer Recovery	Mean ± Std Dev	79 ± 10%	76 ± 7%	83 ± 8%	59 ± 12%
Tracer Recovery Control	50 – 110% is UC	100%	100%	99%	82%

General Control Criteria

Under Control (UC) is ≤2s of annual mean for that QC type.

Warning (W) is between 2s and 3s of annual mean for that QC type.

Out of Control (OC) is ≥2s of annual mean for that QC type.

^aMinimum detectable activity.

^bStatement of work.

Table 4-34. QC Performance Evaluation for Stack Sampling for CY 2001

Evaluation Performed	Stacks Acceptance Criteria	²¹⁰Po	²¹⁰Pb	⁹⁰Sr
Laboratory Control	100 ± 10% UC	80% UC	40% UC	100% UC
Standard (LCS)	80 – 90 or 110 – 120% W	20% W	60% W	
Recovery Check	< 80 or >120% OC			
Matrix Blank (MB)	See control criteria below.	100% UC	100% UC	100% UC
Process Blank (PB)	See control criteria below.	100% UC	100% UC	100% UC
Trip Blank (TB)	See control criteria below.	100% UC	100% UC	100% UC
Matrix Spike	Recovery of added spike: 100 ± 10% UC 80 – 90 or 110 – 120% W < 80 or >120% OC	80% UC 20% W	100% UC	100% UC
MDA ^a Achieved	Samples achieving SOW ^b specification.	0%	0%	0%
Analytical Completeness	80% successful analysis of valid samples.	100%	100%	100%
Tracer Recovery	Mean ± Standard Dev.	64 ± 8%	83 ± 3%	79 ± 5%
Tracer Recovery Control	50 – 110% is UC	96%	100%	100%

General Control Criteria

Under Control (UC) is ≤2s of annual mean for that QC type.

Warning (W) is between 2s and 3s of annual mean for that QC type.

Out of Control (OC) is ≥3s of annual mean for that QC type.

^aMinimum detectable activity.^bStatement of work.

4. Air Surveillance

Table 4-35. QC Performance Evaluation for NonRadNet Sampling for CY 2001

Evaluation Performed	Acceptance Criteria	Beryllium	Inorganic Elements	Total Suspended Particulates	Volatile Organic Compounds
Laboratory Control Standard (LCS) Recovery	ESH-17 criteria shown below.	33% UC 56% W 11% OC	71% UC 15% W 14% OC	NA ^a	75% UC 19% W 6% OC
Laboratory Control Standard Duplicate (LCSD) Recovery	ESH-17 criteria shown below.	NA	NA	NA	74% UC 20% W 6% OC
Laboratory Control Standard (LCS) Recovery	S-T criteria shown below.	NA	NA	NA	98% UC 2% OC
Laboratory Control Standard Duplicate (LCSD) Recovery	S-T criteria shown below.	NA	NA	NA	98% UC 2% OC
Laboratory Control Standard Relative PerCent Difference	Established by Chem. Lab, Varies with Analyte	NA	NA	NA	100% UC
Surrogate Recovery Summary	See Note Below.	NA	NA	NA	99.3% UC 0.7% W
Surrogate Recovery by Compound	See Note Below.	NA	NA	NA	(1) 97 ± 7% (2) 93 ± 4% (3) 105 ± 5% (4) 84 ± 8% (5) 102 ± 4%
Analytical Completeness	80% Successful Analysis of Valid Samples	100%	100%	100%	100%

General Control Criteria

Under Control (UC) is $\leq 2s$ of annual mean for that QC type.

Warning (W) is between $2s$ and $3s$ of annual mean for that QC type.

Out of Control (OC) is $\geq 3s$ of annual mean for that QC type.

ESH-17 Laboratory Standard Control criteria for Be, Inorganics, and VOC:

Be and Inorganics: UC is $100 \pm 10\%$; W is $80-90$ or $110-120\%$; and OC is <80 or $>120\%$

VOC: UC is $100 \pm 20\%$; W is $70-80$ or $120-130\%$; and OC is <70 or $>130\%$

Severn-Trent Laboratories LCS criteria for VOC:

These vary with compound and are based upon their historical experience; none are specified in EPA TO-14.

Performance is evaluated against each compound's specific limits and then summarized.

VOC Surrogate Compounds: (1)= 1,4-Dichlorobutane

(2)= 2-Bromo-1,1,1-trifluoroethane

(3)= 4-Bromofluorobenzene

(4)= Fluorobenzene

(5)= Toluene-d8

Acceptance criteria: UC is $100 \pm 30\%$ ($\pm 2s$); W is $55-70$ or $130-145\%$ (between $2s$ and $3s$); OC is <55 or $>145\%$ ($>3s$)

^aNA = not applicable.

J. Figures

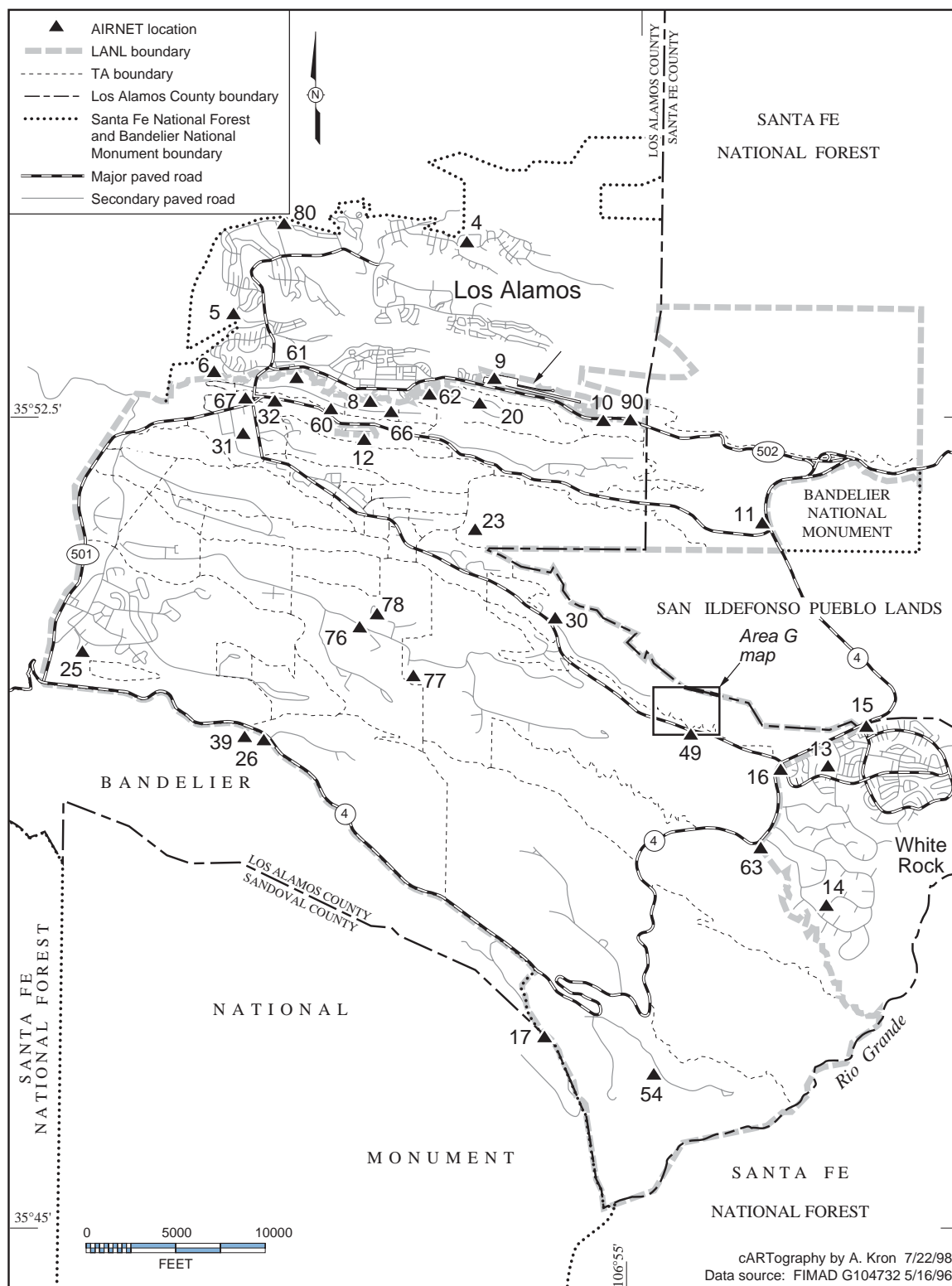


Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

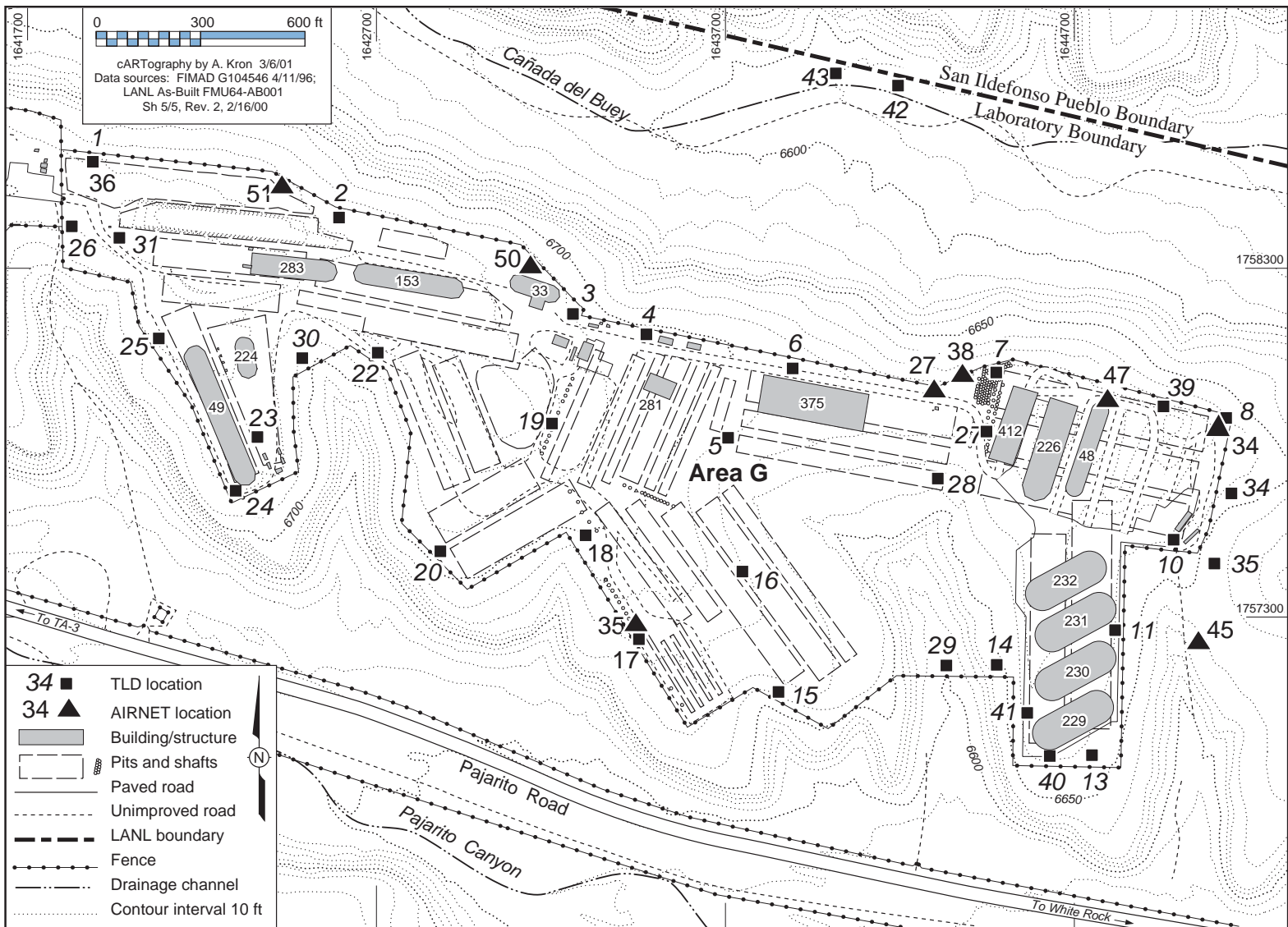


Figure 4-2. Technical Area 54, Area G, map of AIRNET and TLD locations.

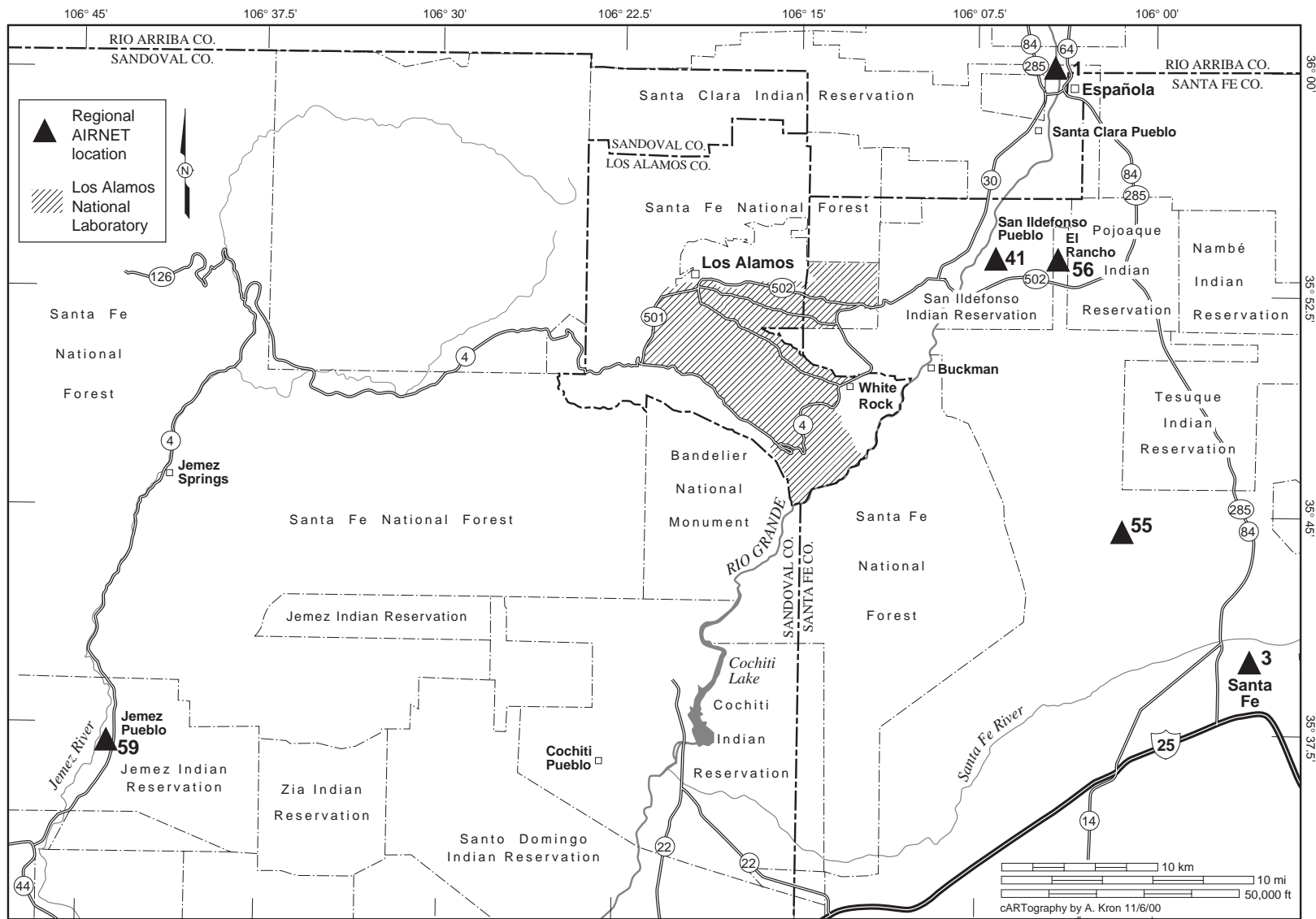


Figure 4-3. Regional and pueblo AIRNET locations.

4. Air Surveillance

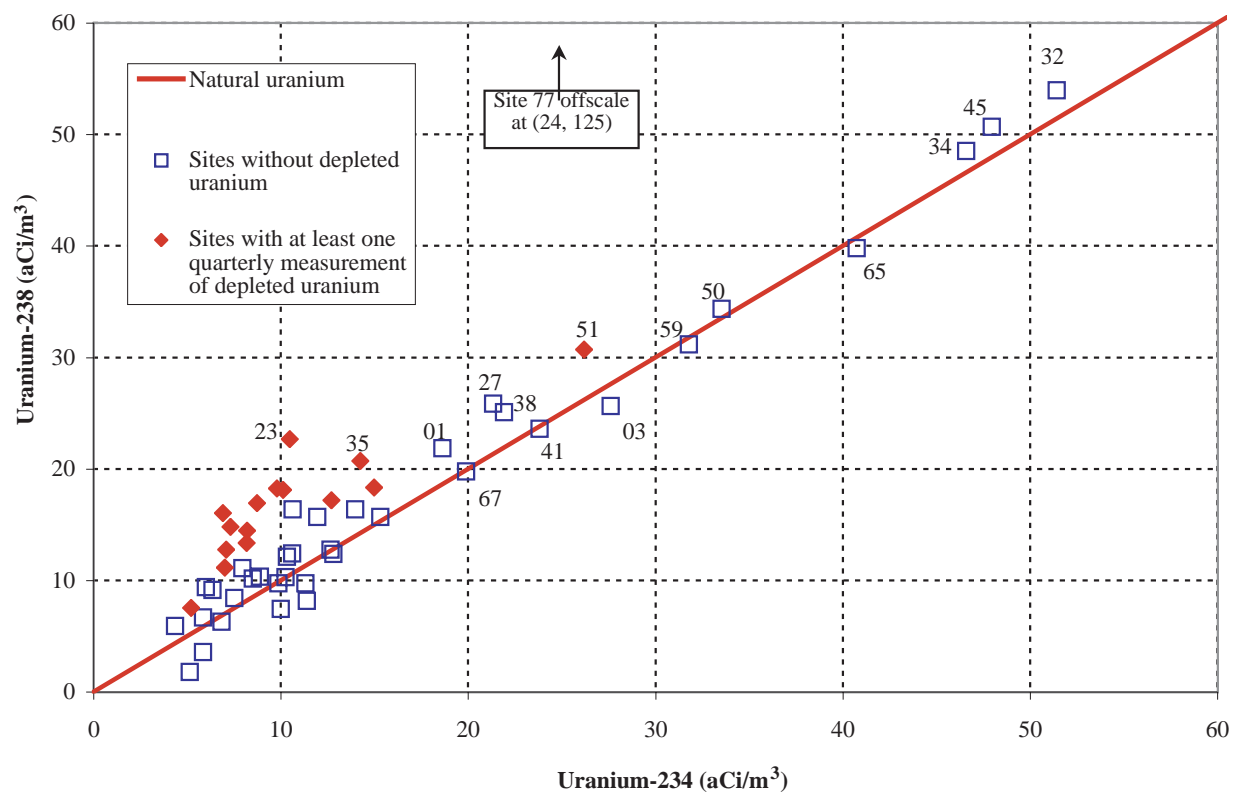


Figure 4-4. AIRNET uranium concentrations for 2001.

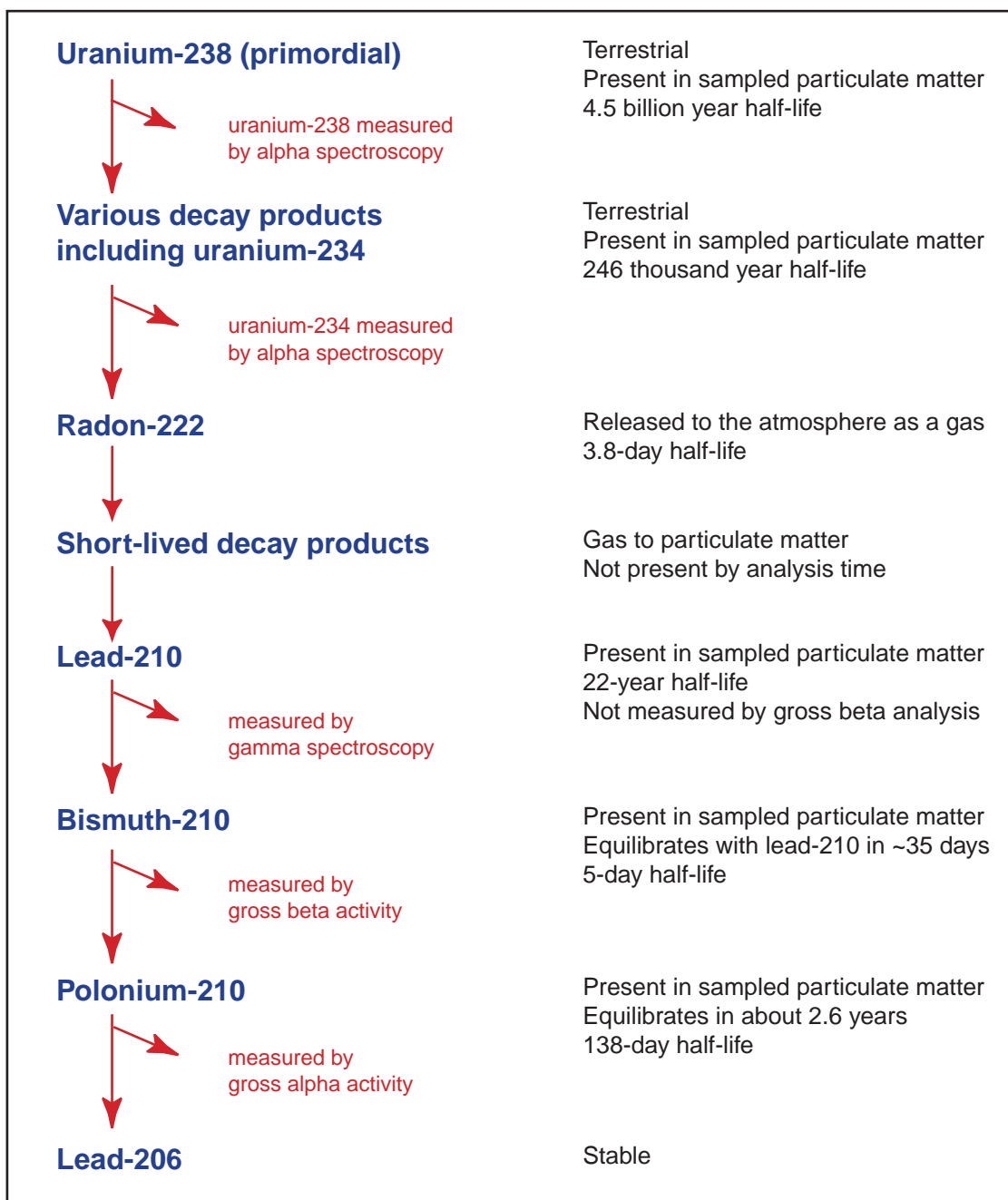


Figure 4-5. Uranium-238 decay series.

4. Air Surveillance

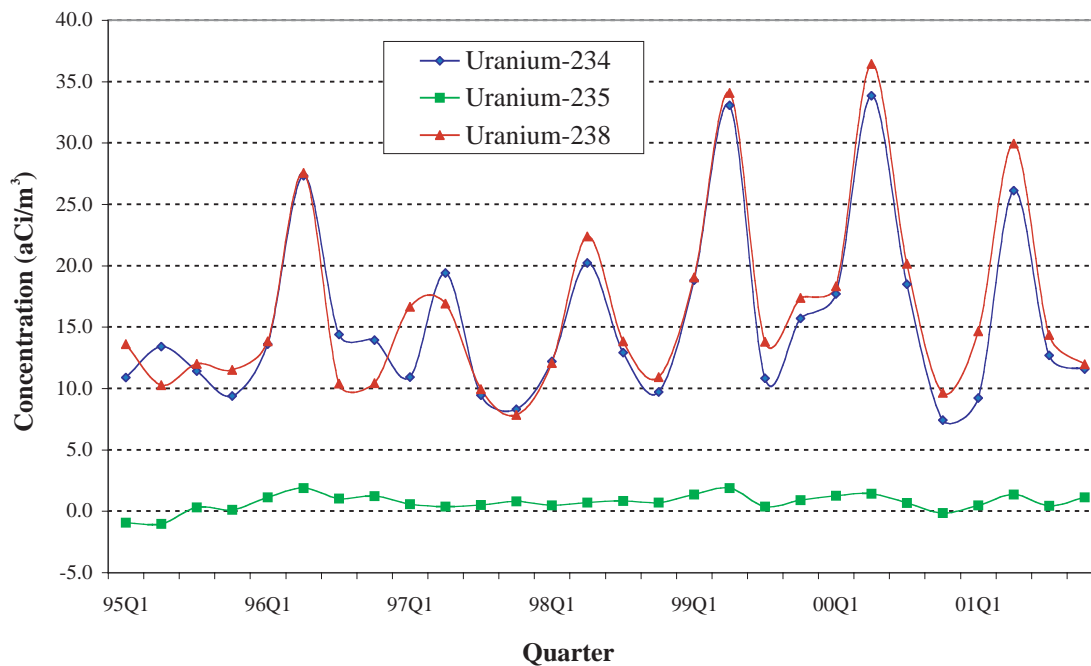


Figure 4-6. AIRNET quarterly uranium concentrations (network-wide concentrations excluding site 77).

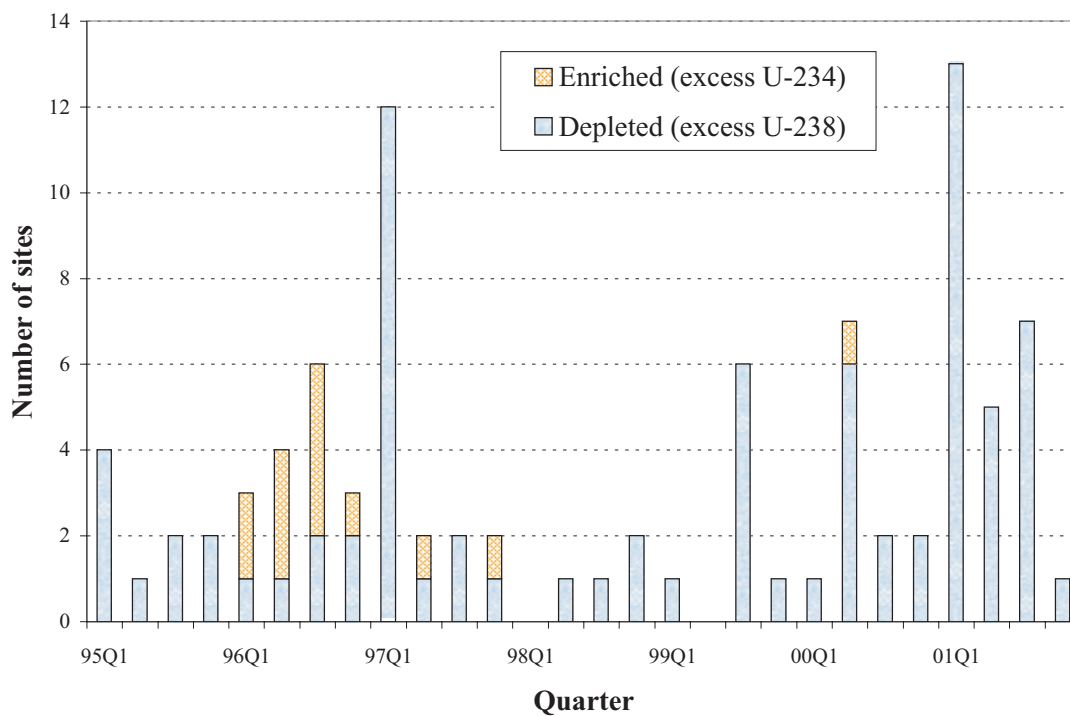


Figure 4-7. AIRNET sites with excess isotopic uranium.

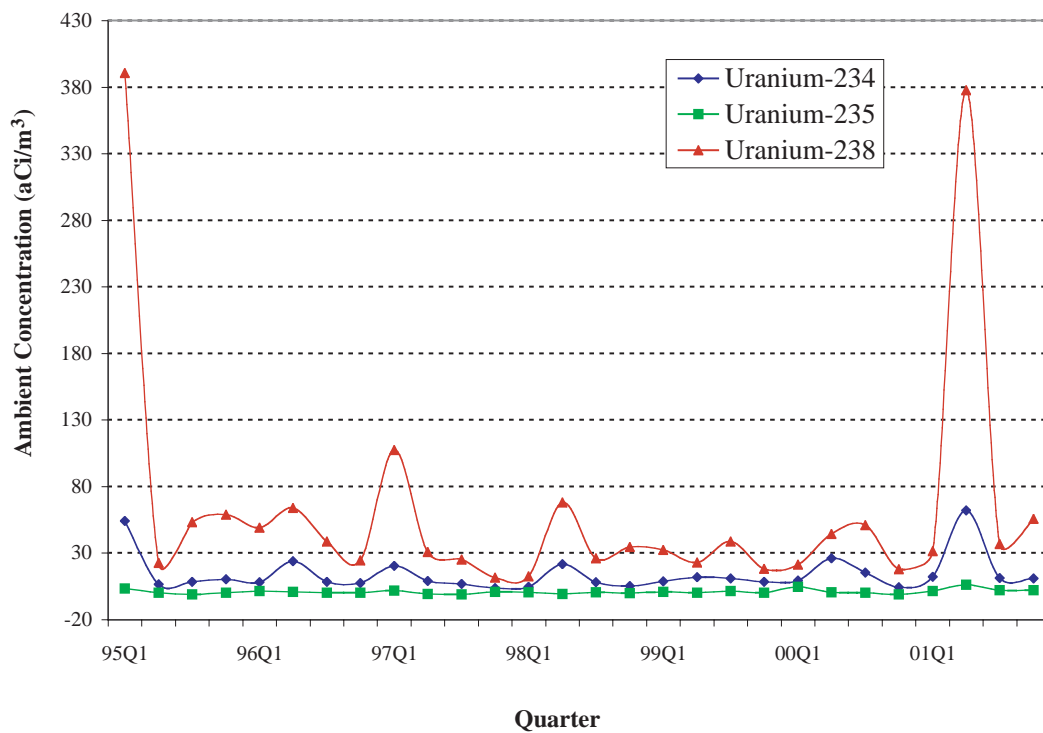


Figure 4-8. Uranium concentrations at site 77.

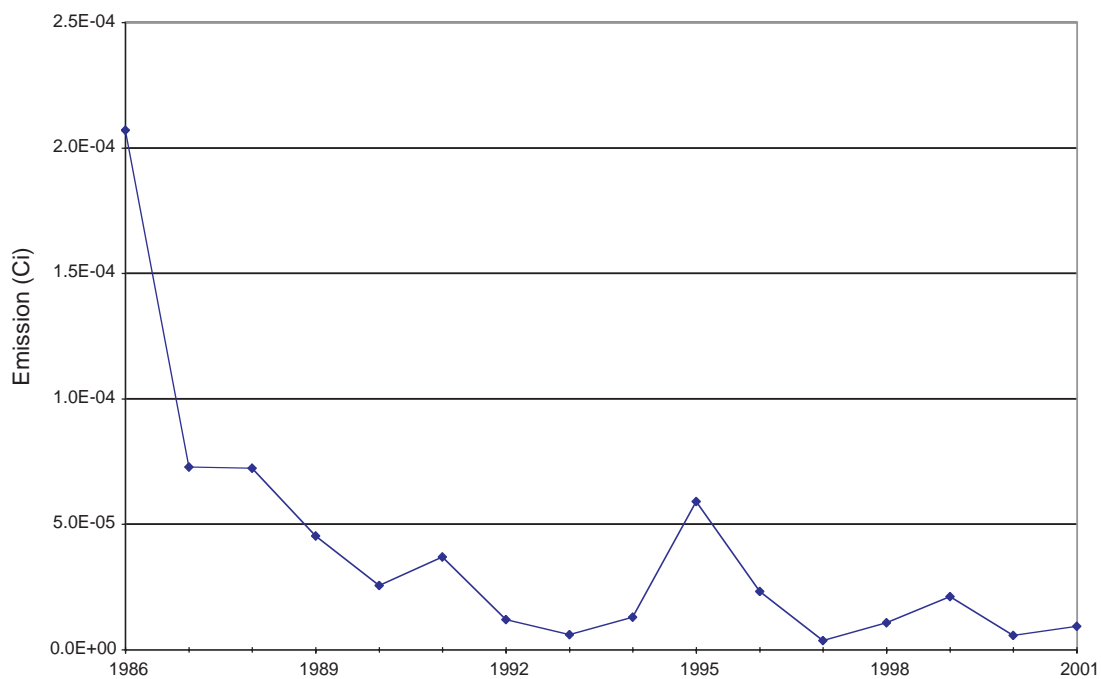


Figure 4-9. Plutonium emissions from sampled Laboratory stacks since 1986.

4. Air Surveillance

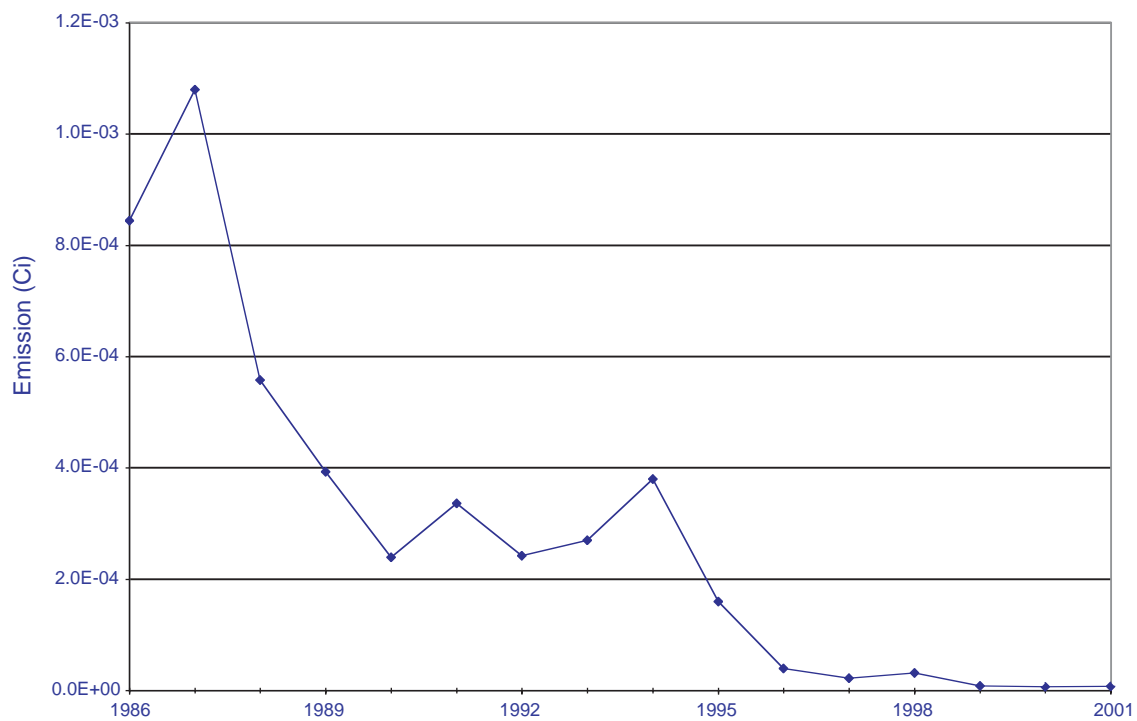


Figure 4-10. Uranium emissions from sampled Laboratory stacks since 1986.

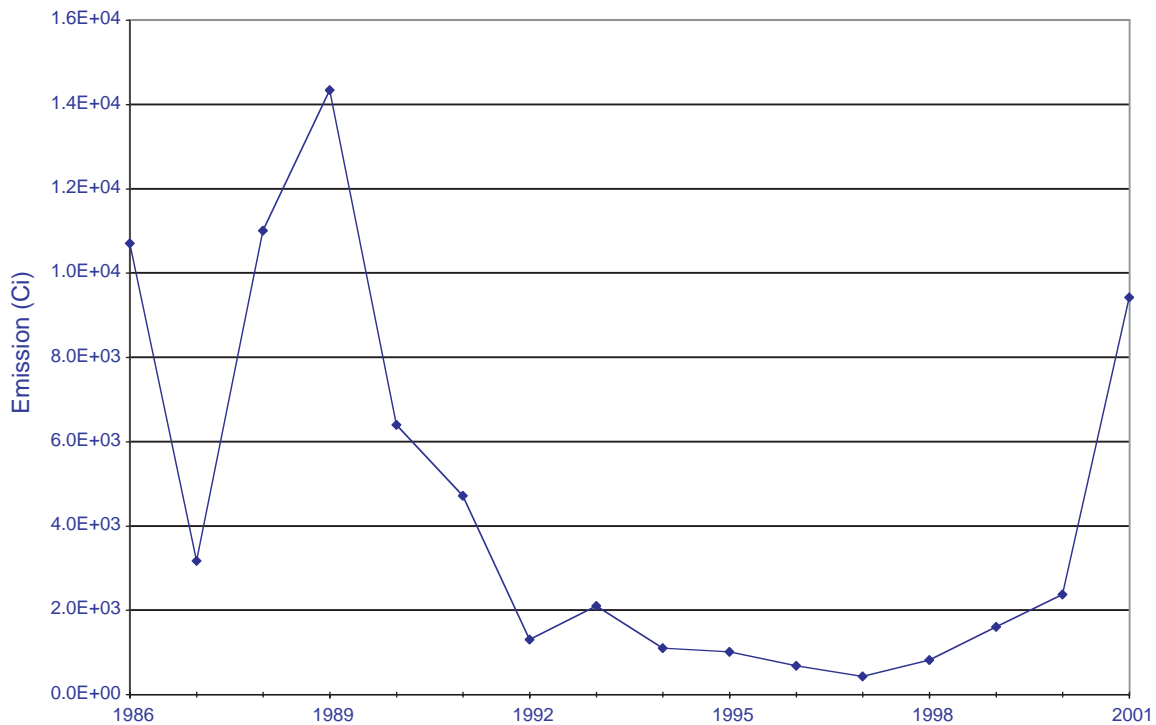


Figure 4-11. Tritium emissions from sampled Laboratory stacks since 1986.

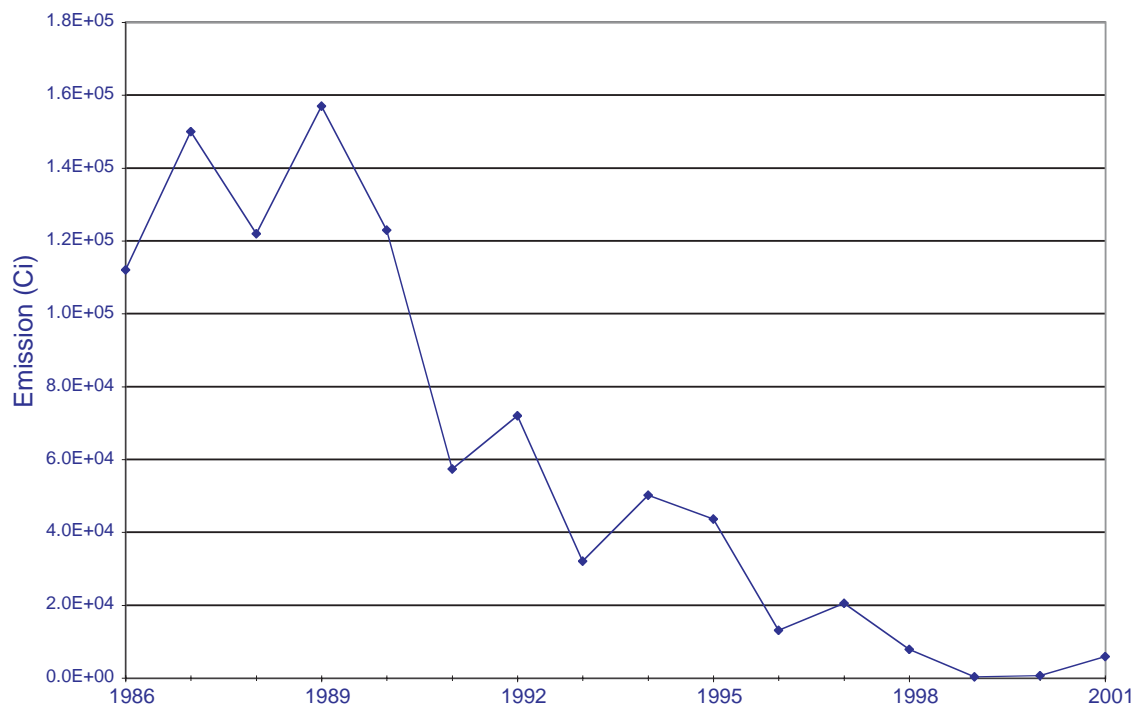


Figure 4-12. G/MAP emissions from sampled Laboratory stacks since 1986.

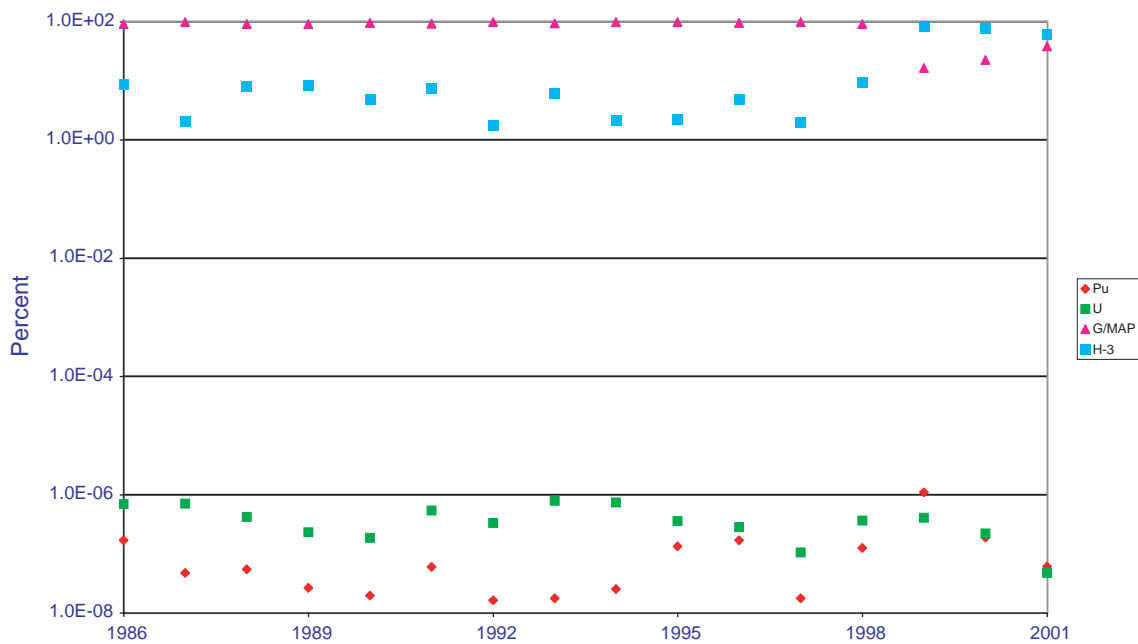


Figure 4-13. Percent of total stack emissions resulting from plutonium, uranium, tritium, and G/MAP.

4. Air Surveillance

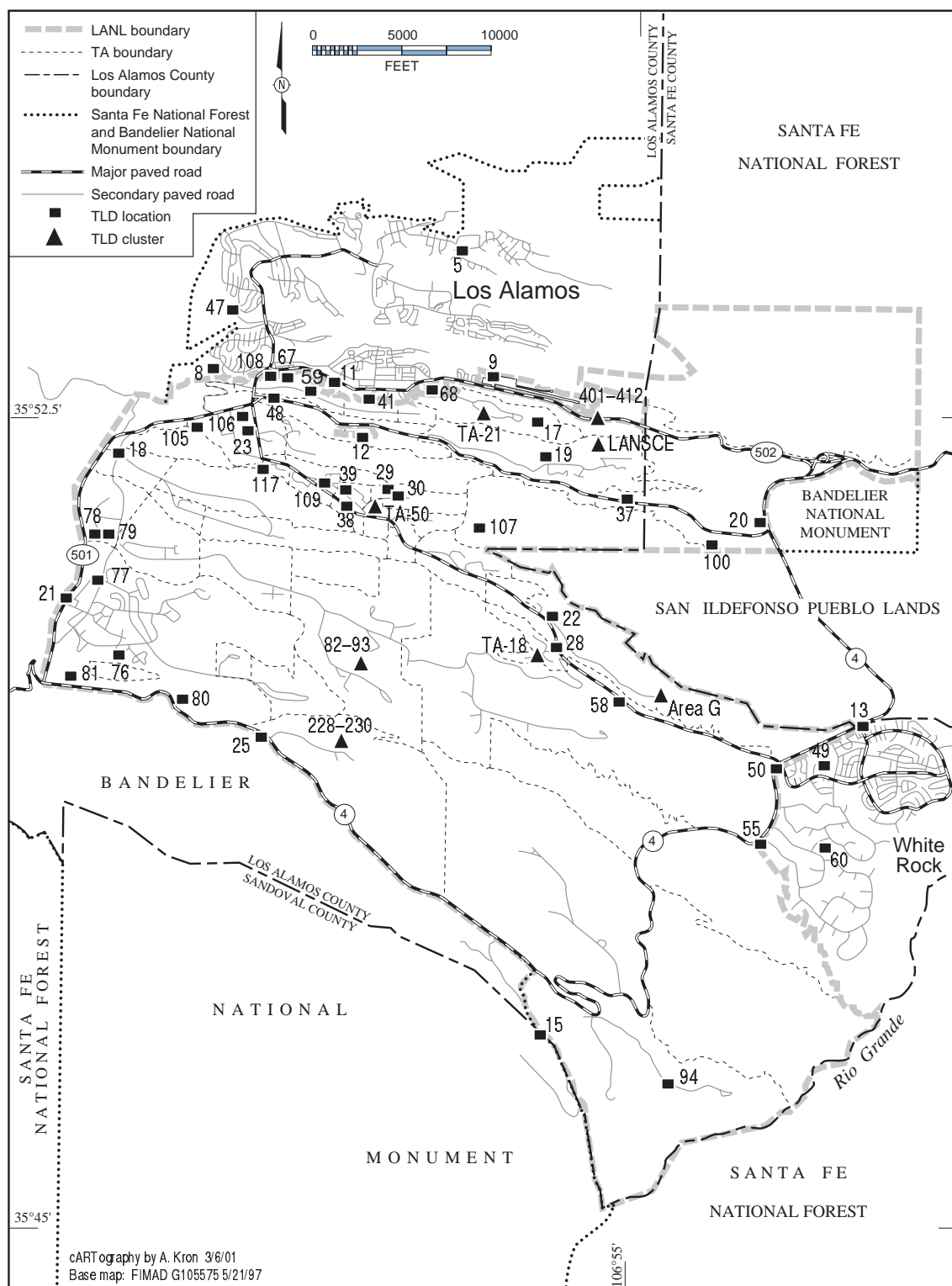


Figure 4-14. Off-site perimeter and on-site Laboratory TLD locations.

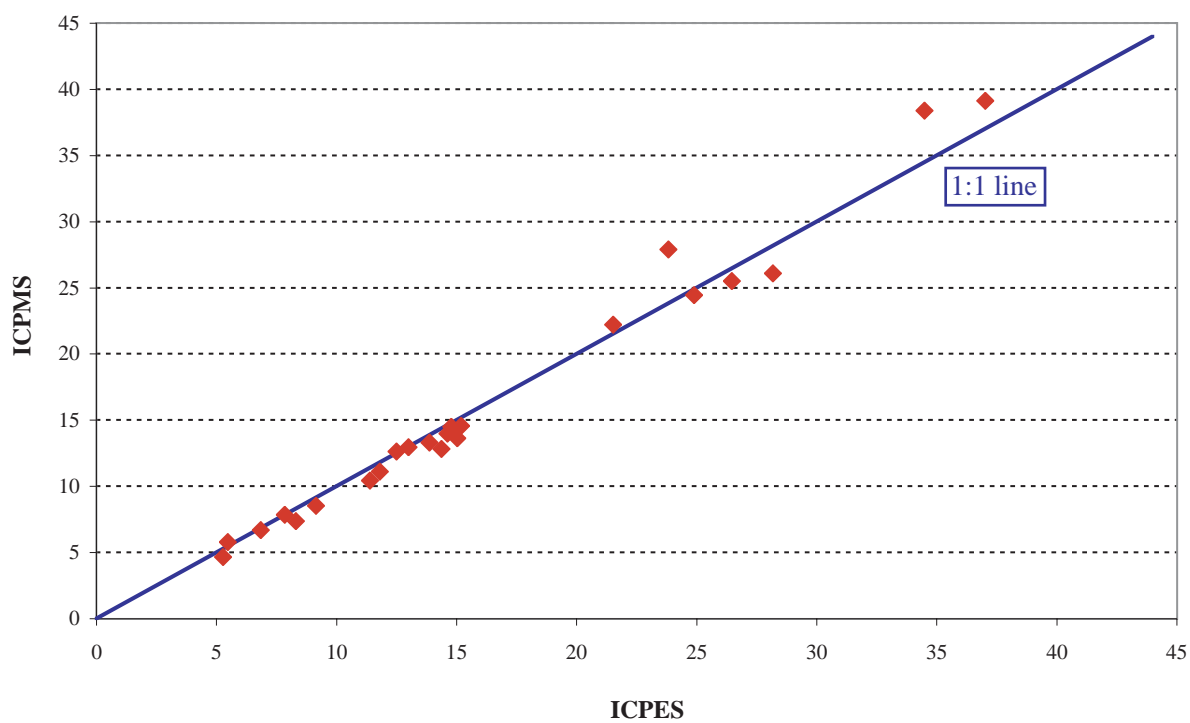


Figure 4-15. ESH-17 barium measurements by ICPES and ICPMS.

4. Air Surveillance

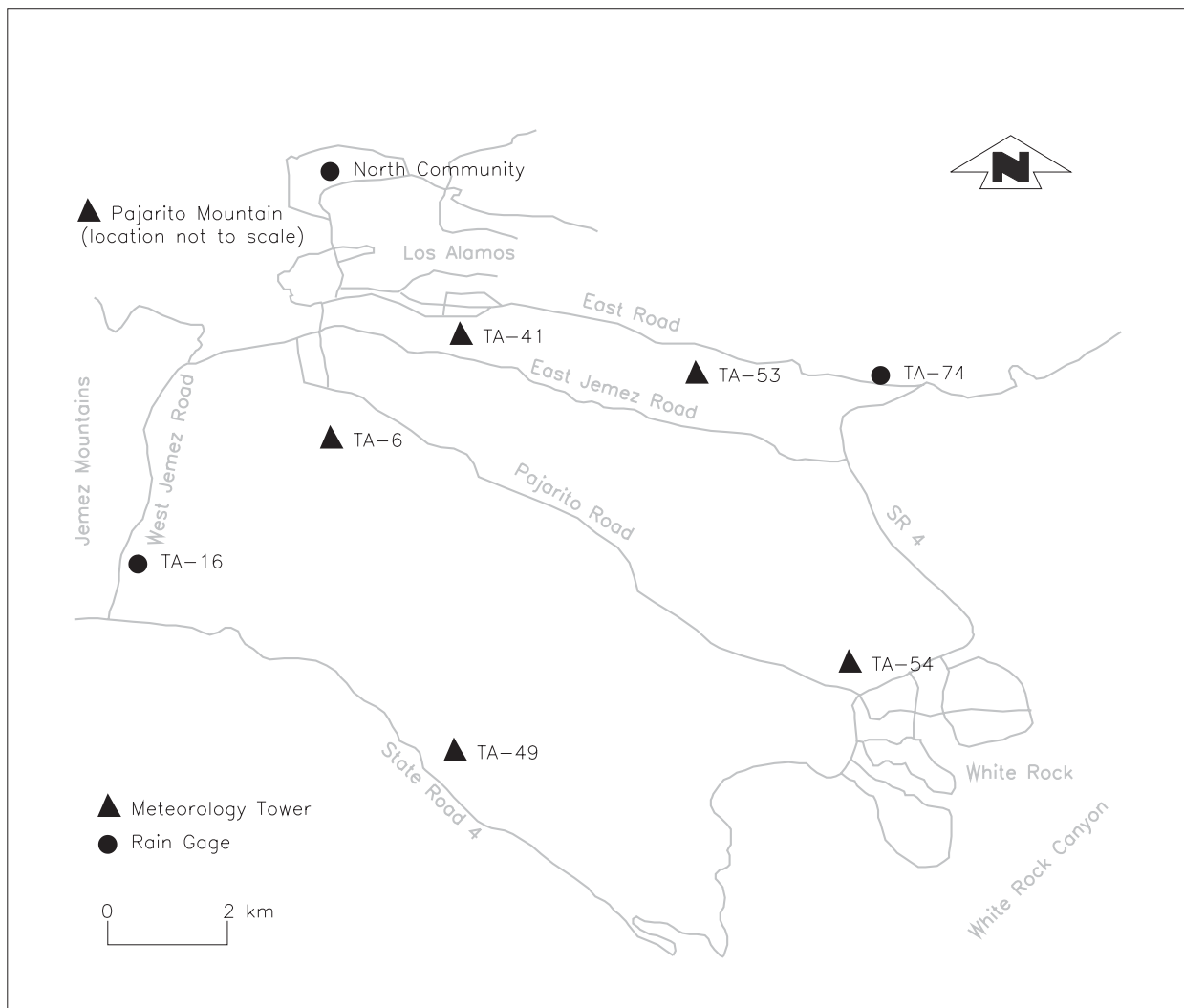


Figure 4-16. Meteorological network.

4. Air Surveillance

Los Alamos, New Mexico - TA-6 Station, Elevation 7424 ft

■ 2001 Values ▨ [Normal Values] 1931-2000

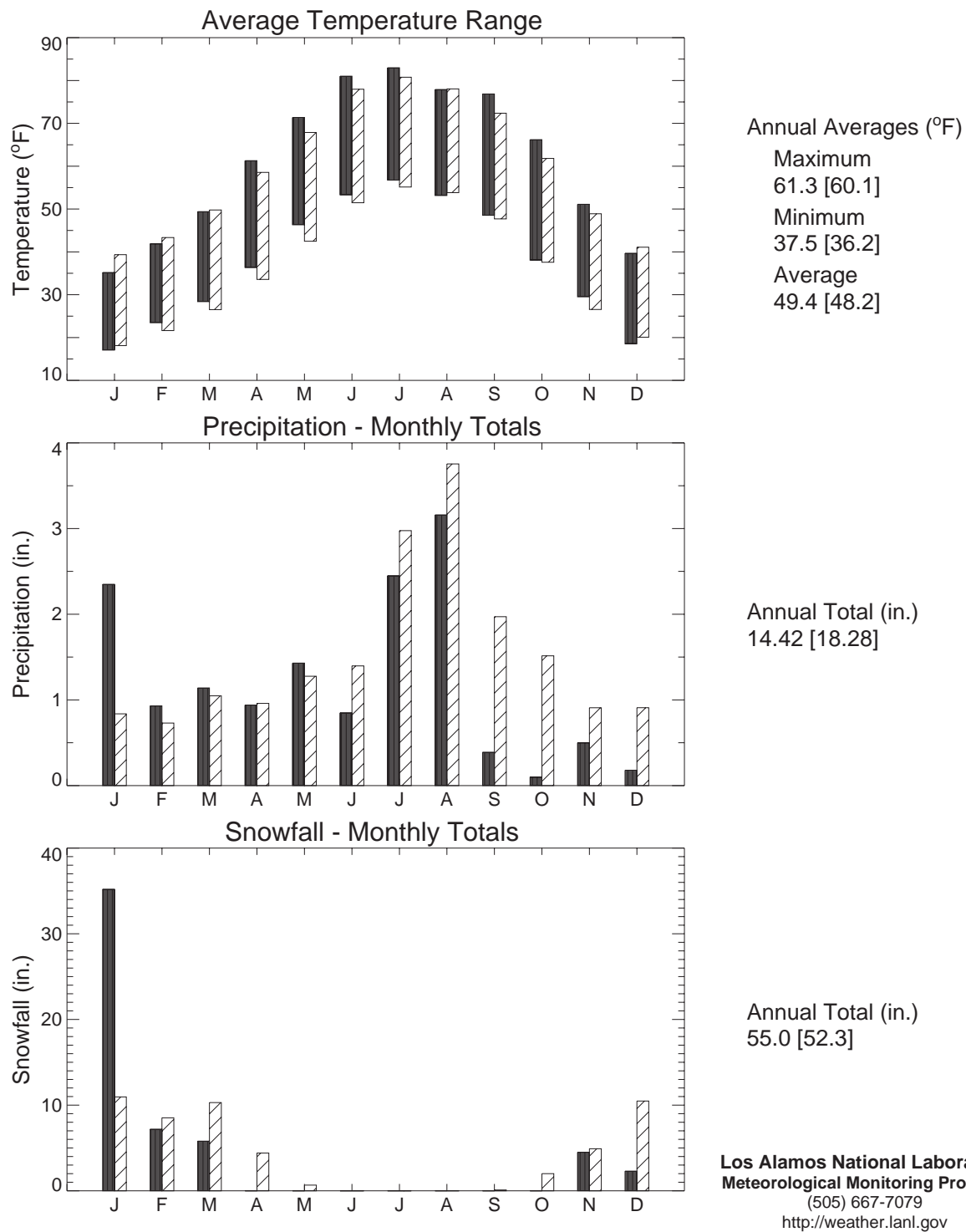


Figure 4-17. 2001 weather summary for Los Alamos.

4. Air Surveillance

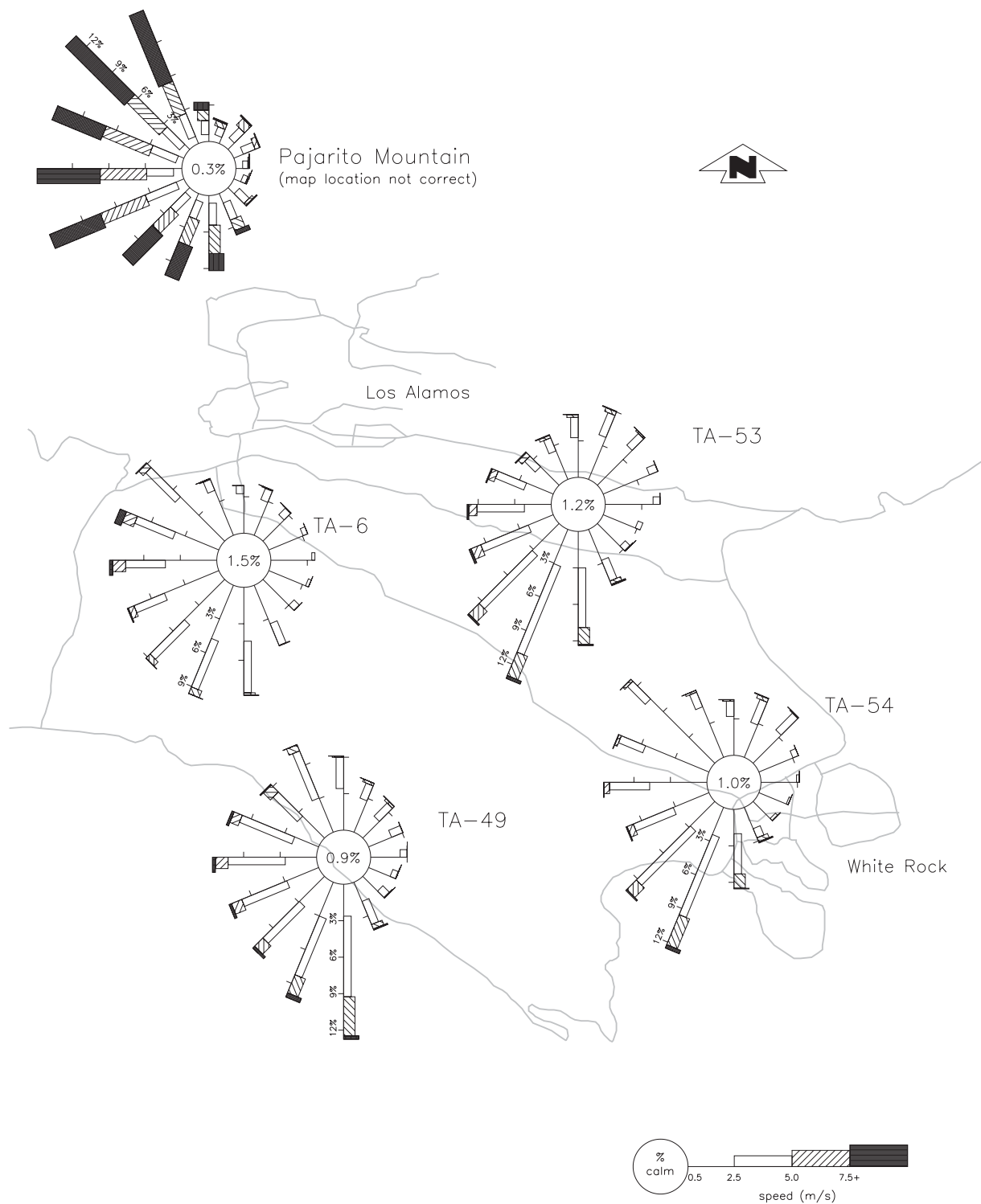


Figure 4-18. 2001 total wind roses.

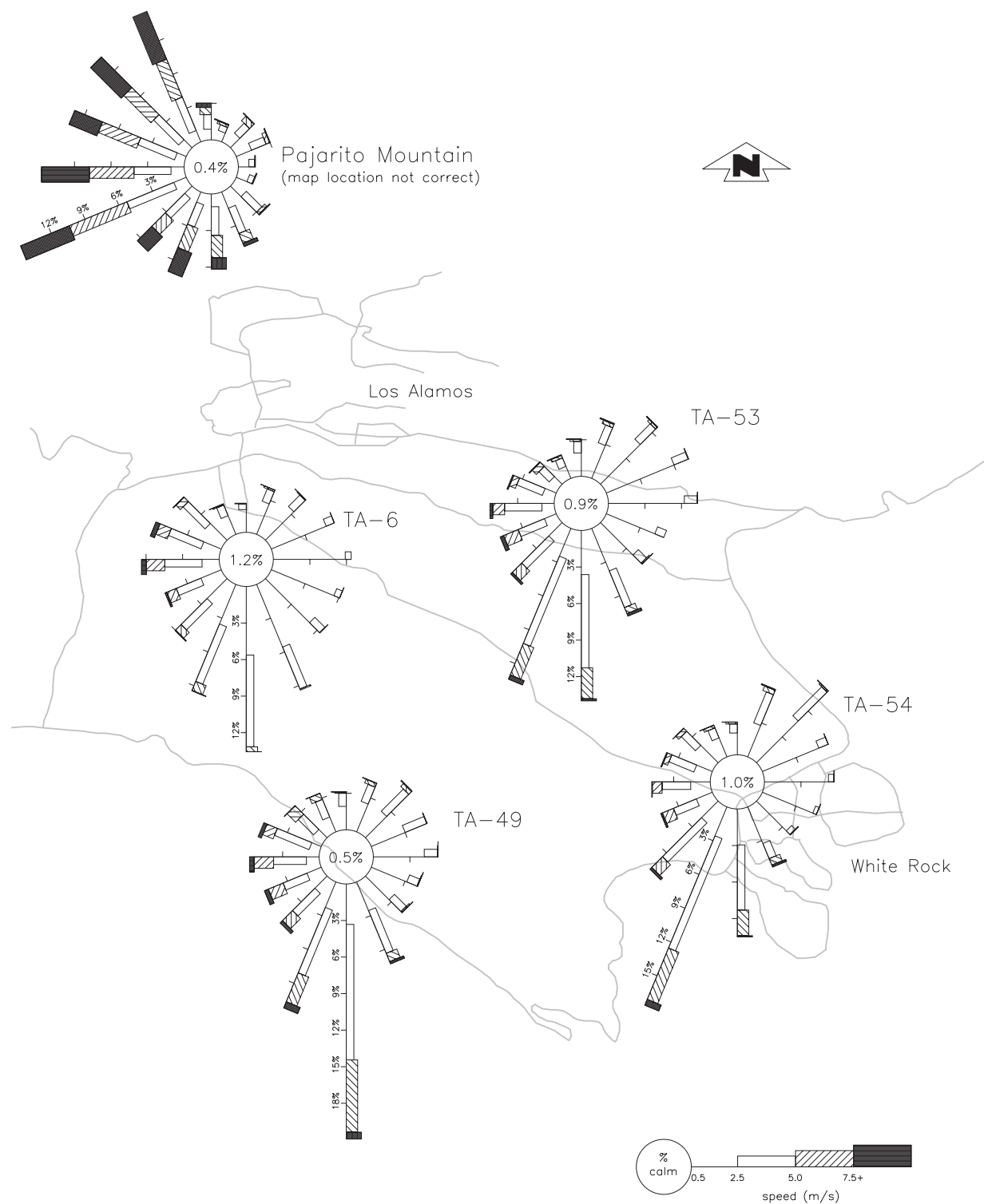


Figure 4-19. Daytime wind roses.

4. Air Surveillance

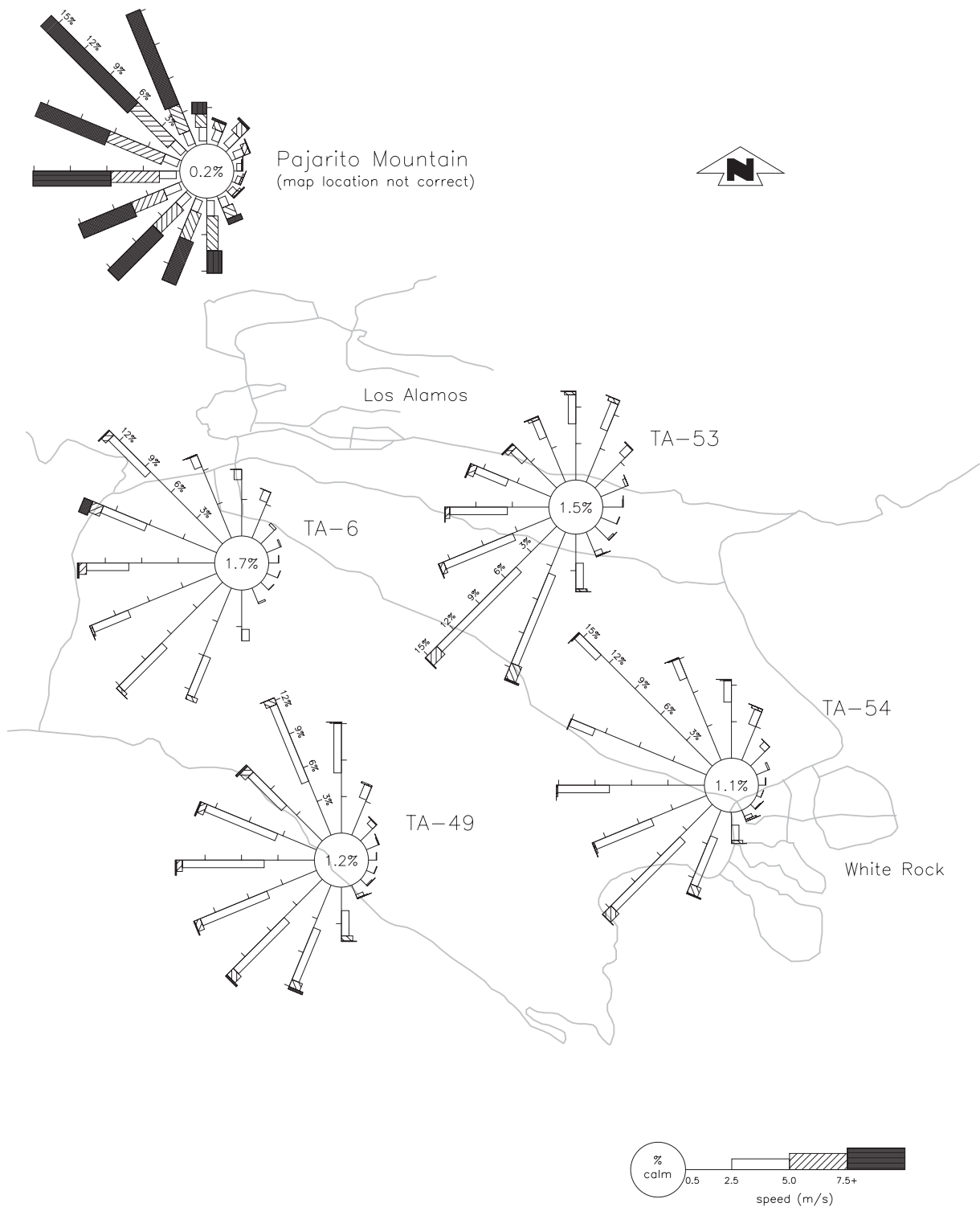


Figure 4-20. Nighttime wind roses.

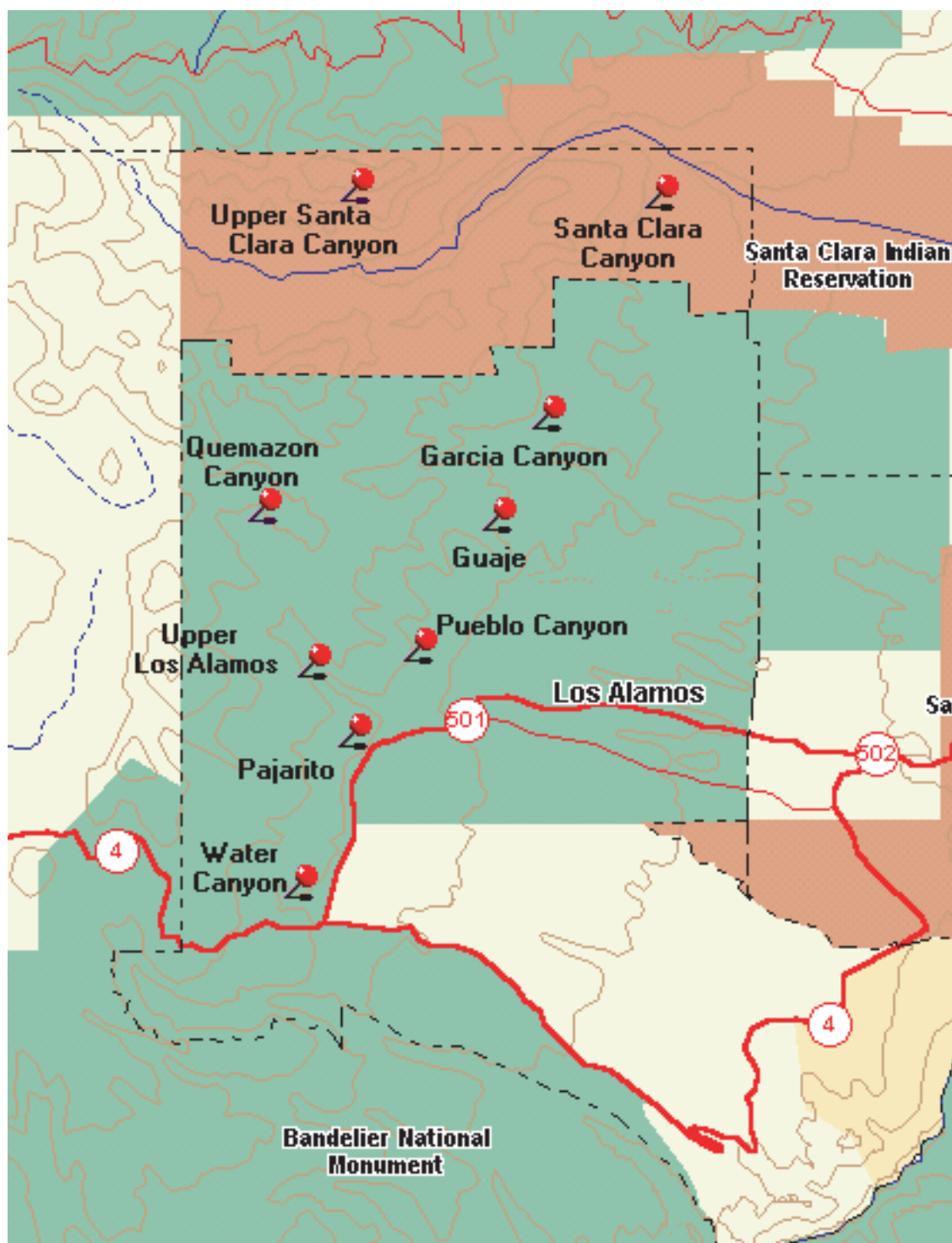


Figure 4-21. LANL Remote Automated Weather Station (RAWS) locations.

4. Air Surveillance

K. References:

- Baars et al., 1998: J. Baars, D. Holt, and G. Stone, "Meteorological Monitoring at Los Alamos," Los Alamos National Laboratory document LA-UR-98-2148 (May 1998).
- Bowen 1990: B. M. Bowen, "Los Alamos Climatology," Los Alamos National Laboratory report LA-11735-MS (May 1990).
- Bowen 1992: B. M. Bowen, "Los Alamos Climatology Summary," Los Alamos National Laboratory report LA-12232-MS (March 1992).
- DOE 1988a: US Department of Energy, "Radiation Protection for Occupational Workers," US Department of Energy Order 5480.11 (1988).
- DOE 1988b: US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy DE88-014297 (July 1988).
- DOE 1999: US Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," DOE/EIS – 0238 (January 1999).
- DOE/NV 1998: US Department of Energy/Nevada, "An Aerial Radiological Survey of the Los Alamos National Laboratory and Surrounding Area," by the Remote Sensing Laboratory of Bechtel Nevada, US Department of Energy/Nevada DOE/NV/11718-107 (1998).
- DOE/NV 1999: US Department of Energy/Nevada, "An In-Situ Radiological Survey of Three Canyons at the Los Alamos National Laboratory," by the Remote Sensing Laboratory of Bechtel Nevada, US Department of Energy/Nevada DOE/NV/11718-41 (1999).
- Eberhart 1999: C. F. Eberhart, "Using Absolute Humidity and Radiochemical Analyses of Water Vapor Samples to Correct Underestimated Atmospheric Tritium Concentrations," in Proceedings of the 92nd Annual Meeting of the Air and Waste Management Association, Los Alamos National Laboratory document LA-UR-98-1107 (June 1999).
- Eberhart et al., 1999: C. F. Eberhart, J. M. Dewart, D. H. Kraig, and E. S. Gladney, "Detecting Emissions of Uranium Using Ambient Isotopic Measurements" in extended abstracts from "PM-2000: Particulate Matter and Health – The Scientific Basis for Regulatory Decision-Making," Los Alamos National Laboratory document LA-UR-99-5724 (January 2000).
- EG&G 1989: EG&G Energy Measurements, "Technical Area 15 and Surroundings Los Alamos National Laboratory," by the Remote Sensing Laboratory of EG&G/EM for the US Department of Energy EGG-10282-1095 (1989).
- EG&G 1990: EG&G Energy Measurements, "Technical Areas 2, 21, and 53 and Surroundings Los Alamos National Laboratory," by the Remote Sensing Laboratory of EG&G/EM for the US Department of Energy EGG-10617-1030 (1990).
- Eisenbud and Gesell 1997: M. Eisenbud and T. Gesell, *Environmental Radioactivity from Natural, Industrial, and Military Sources*, 4th ed., (Academic Press, San Diego, CA, 1997).
- EPA 1989: US Environmental Protection Agency, "National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Title 40, Part 61, Subpart H (December 15, 1989).
- EPA 1999: Environmental Protection Agency Memorandum from R. E. Hanneschlager to D. Gurule, dated March 15, 1999.
- ESH-17 2000: Air Quality Group, "Sampling and Analysis Plan for Radiological Air Sampling Network (AIRNET)," Air Quality Group document ESH-17-AIRNET (August 2000).

- ESH-17 2002: Air Quality Group, "Quality Assurance Project Plan for the Direct Penetrating Radiation Monitoring Network (DRPNET)," Meteorology and Air Quality Group document MAQ-DRPNET R5 (April 2002).
- ESP 1971a: J. Herceg (compiler), "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, January through June, 1971," Los Alamos Scientific Laboratory report LA-4871-MS (January 1972).
- ESP 1971b: J. Herceg (compiler), "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, July through December, 1971," Los Alamos Scientific Laboratory report LA-4970 (July 1972).
- ESP 1986: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1986," Los Alamos National Laboratory report LA-10992-ENV (April 1987).
- ESP 1987: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1987," Los Alamos National Laboratory report LA-11306-ENV (May 1988).
- ESP 1988: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1988," Los Alamos National Laboratory report LA-11628-ENV (June 1989).
- ESP 1989: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos during 1989," Los Alamos National Laboratory report LA-12000-ENV (December 1990).
- ESP 1998: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1997," Los Alamos National Laboratory report LA-13487-ENV (September 1998).
- ESP 1999: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1998," Los Alamos National Laboratory report LA-13633-ENV (September 1999).
- ESP 2000: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1999," Los Alamos National Laboratory report LA-13775-ENV (December 2000).
- ESP 2001: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory report LA-13861-ENV (October 2001).
- Gladney and Luedeker 2001: E. S. Gladney and A. Luedeker, "Final Report, LANL ESH-17 Assessment of the Radiochemistry Facilities at Wastren, Inc., Grand Junction, CO, September 10–12, 2001," ESH-17:01-542, letter to Ron Chessmore, Wastren Analytical Laboratory, December 19, 2001.
- Gladney and Morgan 2002: E. S. Gladney and T. L. Morgan, "Final Report, LANL ESH-17 Assessment of Paragon Analytics Quality Program, October 11–12, 2001," ESH-17:02-083, letter to Debra Henderer, Paragon Analytics, Inc., February 26, 2002.
- Hoffman 1971: G. L. Hoffman, Ph.D. Thesis, University of Hawaii, 1971.
- Lochamy et al., 2001: T. W. Nelson, A. Luedeker, and J. C. Locahmy, "Final Report, ESH-17 Assessment of ESH-4 Health Physics Analytical Laboratory—July 17–19, 2001," ESH-17:01-429, memo to Robert Martin, Health Physics Analysis Laboratory, September 17, 2001.
- Longmire et al., 1996: P. A. Longmire, S. L. Reneau, P. M. Watt, L. D. McFadden, J. Gardner, C. J. Duffy, and R. T. Ryt, "Natural Background Geochemistry, Geomorphology, and Pedogenesis of Selected Soil Profiles and Bandelier Tuff Los Alamos, New Mexico" Los Alamos National Laboratory report LA-12913-MS (1996) <http://lib-www.lanl.gov/la-pubs/00318480.pdf>.
- Mason 1966: B. Mason, *Principles of Geochemistry*, Second edition (J. Wiley and Sons, New York, 1966).
- McNaughton 2000: M. W. McNaughton, "Environmental Neutron Monitoring," Los Alamos National Laboratory memorandum ESH-17:00-322, thru Doug Stavert (ESH-17) and Joe Graf (ESH-DO), to Robert Devine (ESH-4), June 13, 2000.

4. Air Surveillance

- McNaughton et al., 2000: M. W. McNaughton, D. H. Kraig, and J. C. Lochamy, "Siting of Environmental Direct-Penetrating-Radiation Dosimeters," Los Alamos National Laboratory document LA-UR-00-1168 (2000).
- Morgan et al., 2002: T. Morgan, P. Beaulieu, and T. Stirrup, "Final Report, LANL ESH-17 Assessment of STL-Austin Quality Program, December 11–12, 2001," ESH-17:02-093, Letter to Linda Voigt, STL-Austin, March 6, 2002.
- NCRP 1975: National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," National Council on Radiation Protection and Measurements report 45 (November 1975).
- NCRP 1976: National Council on Radiation Protection and Measurements, "Structural Shielding Design and Evaluation for Medical Use of X-rays and Gamma Rays of Energies up to 10 MeV," National Council on Radiation Protection and Measurements report 49 (1976).
- NCRP 1987: National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements report 93 (September 1987).
- Rossen et al., 2000: R. Rossen, R. Jakiel, S. Klima, B. Kahn, and P. Fledderman, "Correcting Tritium Concentrations in Water Vapor Monitored with Silica Gel," *Health Physics* **78**(1), 68–73 (2000).
- Taylor 1964: S. R. Taylor, "Abundance of Chemical Elements in the Continental Crust: A New Table," *Geochim. Cosmochim. Acta* **28**: 1273 (1964).
- Vinogradov 1959: A. P. Vinogradov, *The Geochemistry of Rare and Dispersed Elements in Soils*, Second English translation (Consultants Bureau, New York, 1959).
- Walker et al., 1989: F. W. Walker, J. R. Parrington, and F. Feiner, *Nuclides and Isotopes*, 14th ed., (General Electric Company 1989).
- Wedepohl 1968: K. H. Wedepohl, "Origin and Distribution of the Elements," *International Series Monographs on Earth Science*, L. A. Ahrens, editor, **30**, 999–1016 (1968).